THROUGH SCIENCE TO GOD

By CHARLES H. TYNDALL, D.D., Ph.D.

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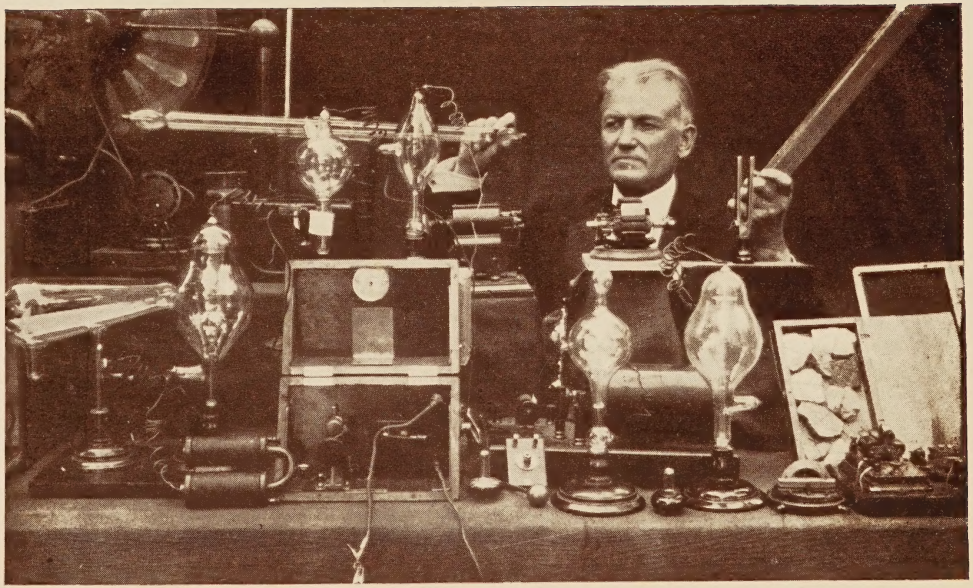

CHARLES H. TYNDALL

The author and a portion of the apparatus which he employed in his "Significant Experiments," explained on page 190.

Through Science to God

NATURE A MEDIUM IN THE REVELATION OF SPIRITUAL TRUTH

By
CHARLES H. TYNDALL, D.D., Ph.D.,
Author of "Electricity and Its Similitudes"

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PREFACE

THE following work is somewhat of a summary of more than thirty-five years of delightful contemplation, study and investigation of the works of nature. The author feels that he has been exceedingly fortunate in inheriting, doubtless from a long line of ancestors, a fascinating interest in scientific things. The joy and excitement of discovering a new operation in nature, and the realization that it had always been there, waiting for each one to find it for himself, have sometimes been so marked that they have left little room for sleep, and have made food seem quite of no consequence.

Some of the material here presented originated long ago while the author, sitting in a forest near the seashore, had séances with nature, observing, contemplating and jotting down the wonders and purposes of God in creation.

The remaining chapters of the book consist of thoughts presented by the author in public lectures which were nearly contemporaneous with the discovery of wireless telegraphy. These have been modified and supplemented from time to time as improvements

and discoveries have followed one another in rapid succession.

The lectures were always given in connection with demonstrations with scientific apparatus. Such experiments were not only followed by keen interest, but were felt to be a complete confirmation of statements of facts which, frequently, would otherwise have seemed beyond belief.

One impression made upon me, and found to be practically universal, covering a period of twenty-five years in lecture work on science, has been the hearty response to moral and religious lessons which science teaches, when the presentations are free from hackneyed religious phraseology, cant and domineering dogmatism.

The facts thus presented were no more heartily welcomed in churches, religious conventions and theological seminaries, than in Chautauquas, schools, universities, technical schools and electrical and other engineering societies. On one occasion electrical specialists, gathered from all leading countries in the world, when they saw the facts and discoveries of wireless and other scientific phenomena proved to be precisely parallel to those which have been taught in the Bible for ages, gave a response which was most sympathetic. Their approval was followed by the writing of a letter in which they expressed their dis-

tinguished appreciation thus: "You have shown us another practical application of electricity for the good of mankind."

In a very few instances religious leaders in churches and army camps who had not previously heard the lectures requested that the religious teachings of science be omitted from the address to be given, because of the presence of persons of all creeds and of none. But later they found their fears groundless; and they became enthusiastic in their realization that science, when rightly understood and interpreted, leads inevitably to God.

One of the pleasures incidental to preparing these lectures for publication is the consciousness of the response which the presentation makes to many requests, uttered by hearers of the addresses, that they be put into print.

C. H. T.

New York.

CONTENTS

PART III

RADIOACTIVITY

ILLUSTRATIONS

INTRODUCTION

NATURE is the Supernatural articulated. It is an expression of God. So far as we know it, man is its culmination and crown.

Being at its head, and having all things unfold in himself, we might expect man to readily understand it; to look through it with ease, as through a transparent medium, and behold God, his Author.

But such is not the case. To man nature has ever been a profound mystery; and it was never more so than now. That which was intended to be a plain pathway leading up to the Father's house, and into the banqueting hall of paternal fellowship, has been to him an enigma.

As door after door is unlocked and thrown open, wondrous things are beheld, but the secret which man has sought eludes him. He seems to be as far as ever from making it his own. Though each new discovery promises to disclose the hidden secret, it proves to be only a beckoning hand urging him ever onward and to penetrate deeper.

The search for this coquetting thing, the secret of nature, is well depicted by the late Dr. Eugene Coleman Savidge in his *Philosophy of Radioactivity:* "Groping darkly, mankind in the past has been vaguely conscious of another, greater force lying parallel with electricity, differing from it yet resem-

bling it. Yet we get evidences of it in the dreams and legends, hallucinations and hopes, in the philosopher's stone, and the fountain of eternal youth. So we come very near the Eternal Constant that stands at the portal of life. The Associative Force is as illusive as when it began linking electrons into atoms, or atoms into molecules. And it eludes us as the elusvie ' thing which changes, at each Eternal Constant.' "

But every locked door has its key—even in nature. Such a key, moreover, because of the unity of nature, when only one has been discovered, is found, like the skeleton key of the chambermaid, to unlock many another door. It thus enables the discoverer to enter and explore many of the multitudinous corridors of God's creation.

Man must be " far-sighted " as well as " near-sighted " if he would discover " the elusive thing which changes." He must be able to see through and beyond the thing close at hand, gaze under the very eyepiece of his microscope, and peer deep into the test-tube in his hand. So the telescopic vision which discerns things and potencies beyond the stars enables him to decipher the hieroglyphics in the atoms, to read the syntonic messages in the blood corpuscles and to get at the very heart of nature, where he can feel her pulses beat in sympathetic rhythm with his own deeper self. Thus the two become intimate friends, the one the complement of the other.

The purpose of the author is to place in the hand of the reader more than one key of the kind referred to above. But let it be understood at the outset that the

prime object of our quest is not simply to wander through the galleries of nature, to behold the beauties and glories of her art on every hand, to marvel at the secrets of bygone ages disclosed to view and to rejoice in the mysteries newly clarified. Nor is it the seeking of wealth in some out-of-the-way cranny till lately overlooked by our predecessors; nor yet to lay hold of nature's secret stores of energy for ourselves or for others. We are to look and learn, indeed, to marvel and rejoice; but we are to pass on, as through a mighty museum or ancestral palace. We are to permit each room through an open door to lead us at last to the throne-room, and into the presence of the King—the King eternal, immortal, invisible, the only wise God our Saviour.

In every age observing and thoughtful people have been impressed by the order and harmony manifest everywhere in nature. These manifestations were seen in the regular and orderly march of the stars, and resulted eventually in the naming of the constellations.

The Greeks, as early as the time of Pythagoras, embodied their impressions of the world in the word Cosmos, to signify nature's system, perfect in order and arrangement, as opposed to Chaos; while the Latins, to denote the world's surpassing loveliness, employed the word Mundus.

Plato, in his Fourth Book, appeals to the order and beauty of the universe as proving the existence of God. Cicero, in his *Treatise on the Nature of the Gods,* speaks of the harmony arising from the dissimilar motions of the heavenly bodies. He says that such

order and ornament could not have proceeded from bodies running together hither and thither and by accident. Plutarch ascribes men's general agreement as to the existence of God to their observation of the constant order and motion of the stars.

In modern times Snowden expresses it thus: "God is mirrored in man as the great globe of the sun is mirrored in the dewdrop. The world as a manifestation of thought, sensibility and will, cohering in unity, is a revelation of God. The pattern wrought in the veil or film of our consciousness is but the face of God impressing Himself, line by line and point by point, upon us. In experiencing the phenomenal world, we are thus gazing upon the immediate manifestation of God; we are directly experiencing His thought and sensibility and will; we are beholding Him face to face."[1]

Dr. Robert A. Millikan remarks: "Every one who reflects at all believes, in one way or another, in God. For it is to me unthinkable that a real atheist should exist at all."

The Apostle Paul says that ever since the creation of the world God's invisible nature—His eternal power and divine character—have been clearly perceptible through what He has made.

We might truthfully add that those persons who will study nature—not merely grant it an occasional and superficial glance—and will reverently dwell upon it, noting its intricate systems, marvels and extent, will not only see God in and through it, but will find a

[1] *The World a Spiritual System,* Dr. J. H. Snowden.

joyous reward in the discovery that as their knowledge increases their conceptions of Him enlarge also.

This is the thought indicated in the poem by S. W. Foss:

A boy was born 'mid little things,
  Between a little world and sky,
And dreamed not of the cosmic rings
  Round which the circling planets fly.

He lived in little works and thoughts,
  Where little ventures grow and plod,
And paced and ploughed his little plots,
  And prayed unto his little God.

But as the mighty system grew,
  His faith grew faint with many scars,
The cosmos widened in his view—
  But God was lost among his stars.

Another boy in lowly days,
  As he, to little things was born,
But gathered lore in woodland ways
  And from the glory of the morn.

As wider skies broke on his view,
  God greatened in his growing mind;
Each year he dreamed his God anew,
  And left his older God behind.

He saw the boundless scheme dilate,
  In star and blossom, sky and clod;
And, as the universe grew great,
  He dreamed for it a greater God.

The veil between the natural and spiritual worlds is a very thin one, almost transparent to one possessed with the telescopic vision. By suggested analogies

such a one is led from the lower to the higher, from the visible to the invisible. Let no one belittle the reasoning from analogy. Professor Cooke of Harvard in his work, *Credentials of Science,* asserts: "There can be no question that the suggestions of analogy have led to more discoveries in science than all other influences combined."

Janet, in his *Final Causes,* says: "It is certain that it is by an analogical reasoning that we affirm intelligence in our fellow-men; on the other hand, it is undeniable that this belief equals in certitude any other of our affirmations. Analogy may therefore have a force of proof equal to that which any of our faculties can give. To conclude from the likeness of apparent qualities to the likeness of hidden qualities is precisely what is called analogy."

As the suggestions of analogy so often prove to be the key which enables man to unlock the secrets of nature, so likewise reasoning from analogy may as certainly impart to him a knowledge of the spiritual realm.

So we are brought to the proposition that we may be led through science to God—that nature is a medium in the revelation of spiritual truth.

PART I

NATURE A MEDIUM IN THE REVELATION OF SPIRITUAL TRUTH

I

NATURE HAS A THREEFOLD INFLUENCE UPON MAN

WHEN we consider the influence exerted by nature upon man physically, we perceive that man's body springs from mother earth, receives its nourishment from her bosom, is developed by her hand and then sinks back into her embrace.

The germ of physical life is rooted in nature, and in its development it transforms and carries up into the higher life that which is below.

Man's body is largely affected by the kind, quality and quantity of food supplied by nature. In cold, oil-eating climates, such as those inhabited by the Esquimaux, the system requires carbonaceous or heat-giving foods to furnish fuel for the warmth of the body; but in temperate or hot climates there is a craving for nitrogenous or flesh-forming foods, and vegetables are in demand.

A change in the character of the food produces a corresponding change in the body, and advances or diminishes its growth, health and strength. The Bulgarians are celebrated the world over for their longevity. It was recently stated by Dr. Lorand of Carlsbad that while Germany has a population of 61,000,000 there are only seventy-one persons in it who are more

than 100 years old, and that Bulgaria with 7,000,000 inhabitants has 3,800 who are over that age. It is asserted that such great age is a result of the people's custom of eating daily their " jogruth " or " yoghurt," a sour milk containing three different microbes which are harmless to man but which destroy the germs that cause auto-intoxication in the digestive tract.

Foods which contain a large quantity of carbohydrates are regarded as very valuable for building up the body and storing it with energy. Of all cereal foods, rice forms the least uric acid and is a very valuable nutritive food. It contains seventy-seven per cent of carbohydrates, and so, in spite of its being poor in mineral matters, is man's most valuable food. The nations of Asiatic countries who live almost entirely on rice offer us examples of great tenacity and of resistance against bodily fatigue. The Japanese are a familiar example. Their coolies perform their incredible muscular efforts largely on this grain as a food. In Europe and America potatoes generally take the place which rice holds in Asiatic countries. Though these are much less rich in nutritive qualities than rice, and are not highly esteemed by many dieticians, they nevertheless, if partaken of in large quantities, have a reputation for preventing diabetes.

It is exceedingly interesting to note the complementary action between nature and our bodies. Nature spreads her table, bountifully supplied for all our needs, in the lacteals and in the chyle which are in the blood. Now, each particular part of the body makes its own choice of the special compounds which are

required for the formation of its own peculiar substance or for the discharge of its special function. The bones specially select and appropriate phosphate of lime, and the muscles take out phosphate of magnesia and phosphate of potash. The cartilages choose and grow on soda; the teeth extract flourine; the hair, skin and nails seize and almost monopolize silica; the eye and hair select iron to form their pigment, and the brain gathers phosphorus.

The liquids which we drink change us, also. The body is composed of at least seventy per cent of pure water, the rest being made up of gases and minerals. Since the body is so largely made up of water, and since the skin alone, every twenty-four hours, exhales, in insensible perspirations, from one and a half to two pounds of water, and the lungs something over one pound, we can readily understand why physicians insistently state that people in general drink too little water. In fact, we should no more wait for a sense of thirst before drinking than we would wait until we have a feeling of suffocation before we inhale more fresh air.

The effects of the atmosphere on the body are marked. Some people have such susceptible nervous organisms that they become aware of atmospheric changes to such a degree that they are, in a measure, living barometers. We speak of a "dull" rainy day because of the effect that the weather has upon us physically; on the other hand, a cool dry atmosphere is bracing and becomes a tonic to the nerves.

Certain regions of the earth, either because of cli-

mate or of a malarious atmosphere, are recognized as exercising detrimental effects on the health of the body; other localities are famous for their healthful influences. The changes in the seasons produce changes in the body; patent-medicine makers reap fortunes in supplying tonics needed in the spring.

The rotation of the earth on its axis, producing the succession of night and day, determines our seasons of rest and work, the time of partaking of our food and our hours of sleep. Through this change nature does more than lay her hand upon our business and regulate all our physical activities; she touches even the pulsations of our lives.

In health the temperature of the body rises to its highest point during the afternoon, and then falls to its lowest after midnight; in some fevers these are the periods of highest and lowest temperatures. Such correspondences of the maxima and minima of the heat of the body to the diurnal rotation of the earth may have resulted originally from adaptations to the periods of human rest and labour. But, since these periods are determined by the rotation of the earth, it is evident that in our bodies the fire of life actually follows the sun, not the vicissitudes of human occupation.

Nature affects the physical frame of man by her refusal to supply him with food or fuel, shelter or clothing and other conveniences without his exertions. We have seen how interesting it is that each organ or function of the body is provided with special faculties to appropriate the food which it needs for its upbuilding, sustenance and operation. Yet, after all, the

benefit to the body does not depend so much on the actual amount of food procured as on the exercise which may be required to obtain it. This fact is so important in the physical economy of the body that exercise is in no small degree the end in view.

Both food and exercise are essential to the life and health of the body. "Without food exercise is impossible, and without exercise food is useless." What a body is, depends upon what it does; its exercise actually makes it. Through labour to attain the necessary and desired objects, man develops skill in the use of his bodily powers. In every effort which the body puts forth to acquire food waste material is cast off, and muscular fibre is added.

Thus nature participates in and furthers the development of the body by holding with a firm hand the very necessities of life—in such a way that these can be obtained only by wrenching them from her grasp; and such effort produces growth. The arm of the blacksmith is made strong by toil.

II

THE INFLUENCE OF NATURE UPON THE MIND

NATURE impresses and influences not only man's body; she reaches deeper and touches, with her fashioning hand, his plastic mind. Man observes and studies the operations of nature until he discovers the manner in which things are uniformly done in it, and then he formulates them into what he terms infallible rules, or " the laws of nature."

These laws he combines and manipulates in a thousand and one ways, one law being made to reinforce, parallel or counteract another, until he compels them all to do his bidding in the marvels which spring from his own mind.

So man dominates nature. He makes it his servant to transport him and his burdens swiftly over land and sea; to carry his messages around the world in a moment of time; to lift him into the air and put to shame the birds by his rapid flight; to explore and navigate at the bottom of the ocean; to delve into the heart of the earth and bring forth treasures stored there for him in the early geological ages; to measure, weigh and analyse the suns and stars; and in countless other ways to reveal the fact that he is made for dominion.

Man controls not only the nature which is exterior

to himself, but that also which is expressed in his own physical being. He investigates himself and his environment and finds similar uniform operations there, and again he proves that he was intended to rule. He repels the diseases which would destroy his life and transforms them into his servants.

Instead of surrendering to the suggestion that he is only the offspring of nature, and that "out of that exceedingly complex organ, the cortex of the brain, arise the energy phenomena of emotions, of love, of hate, of thought, of memory, the conceptions of morals, the faculty of reason and all the higher reaches that characterize his mind and spirit," he knows that, on the contrary, he himself originates all these, that the brain does not "secrete" them much as the liver secretes bile, but that the brain, like all other parts of his body, is his instrument.

Dr. William Hanna Thomson, in his *Brain and Personality,* correctly maintains: "The brain is the instrument of the thinker, as the violin is the instrument of the musician who plays upon it. The most skilled violinist would draw forth nothing but crazy sounds from his instrument if its cords were smeared with grease instead of with rosin." Man's mental disorders, from delirium to coma, correspond with and parallel the "musical derangements which are due to purely structural conditions in the violin itself, and not at all in the performer." It all is due to no fault of his, but solely to conditions in his instrument.

During the first quarter of this century the discoveries in psychology of what man is able to accomplish

by the right or the wrong direction of his mind have been little less than miraculous.

Many pages could be filled with the names of authors who have written on this subject. Among them are those who, in things mental, as students and thinkers, are probably not surpassed in any age. They all teach, as any one himself can prove, that by the right direction of the mind a person can make it well nigh impossible for disease germs to thrive and multiply in his body and that, to a very large extent, he can banish most of the ills to which flesh is heir.

The mind is able to transform the body of even the weakling into that of a giant. A frail person in delirium often requires the strength of several powerful men to overmaster him. Similarly, one who, under influence of hypnotism, is told that he is " the strong man of the age " and that he must prove it by his muscular feats, at once proceeds to put forth strength which in his conscious state he would regard as utterly impossible for him to exert.

The mind is so potent in its influence over the body that death often ensues as a result of expecting it to occur. One may be frightened to death. On the other hand a determined will and strong confidence frequently prove their mastery over failing bodily powers, and revive and restore the sinking one, to the astonishment of friends, and contrary to the expectation of the physician.

The mind can send forth ether waves, produced by the agitation and rupture of brain cells, so powerful that the thinker on the instant arouses corresponding

thoughts in the minds of others, if the conditions be favourable, even though a continent intervene.

All these and countless other marvels which are being wrought by the mind of man are doubtless only a prophecy of what he will be able to accomplish when he arrives at the full realization that he was made to rule—when, putting himself into harmony with God and with the laws of his own being, he accepts the place which was assigned him at his creation.

But great though man is mentally, nature often proves to be his stubborn servant. The instrument gets out of tune, and the musician produces only discords. At his every turn nature is entwined about him, as if she sought to bend him to her ways and would mould him into conformity with herself. At times, he can almost hear her insinuation, "I am Mother Nature; I must teach and train all my children." So she never leaves him; whether he be awake or asleep, sick or well, toiling or feasting, her hand touches him, sometimes gently but often with rigour.

Our environment affects our thoughts. We cannot help thinking of the things which we see, handle, taste and feel. A sunset awakens in us thoughts of the beautiful; unpleasant things suggest thoughts of aversion, fear, hatred, sorrow. These in turn, through the association of ideas, bring to mind other thoughts, scenes and events. The sight of a familiar landscape, or one which is in contrast to it, may call to mind the scenes of childhood or events covering a period of many years.

Dominant local industries inevitably affect the

studies in the schools of any community. Great electrical manufacturing, like that in Schenectady, New York, invites many young men resident near by to shape their careers along electrical lines. It is said that one of the cities on the Pacific coast is situated on a fine harbour which is large enough to afford safe anchorage to 300 battleships, and that it is a rare thing when the harbour is without a considerable number of sea-going vessels. Naturally, then, many of the people look to the ocean for their livelihood. In the school shops nothing else arouses so much interest as the building of boats and of models of racing craft. Another city is the centre of a large quarrying district. In its schools stone drafting and stone working are emphasized, and large numbers of the local boys elect such courses of study.

The same statement could be made of nearly every other industry, whether it be cotton growing, the manufacture of shoes or woolen goods, fruit growing or cattle raising, railroading or mining—all have their appeal to the young who live in their communities. A home in a great university centre suggests a different career than a home in a city which is given up entirely to maritime pursuits.

A mother was at a loss to know why her three sons became seamen though all of their nearer ancestors were farmers. Her attention was called to a large striking picture which had hung on the wall in the home and that had been seen and admired by her sons from their infancy. A beautiful ship, with sails spread, was bounding over the sea; that was the explanation.

A traveller through different communities can but be impressed by the uniformity of the architecture of the houses, the peculiarities of barns which are duplicated, the use of lightning arresters, the similar colours in which the buildings are painted, and even the similar kinds of fences. Such features seen on a neighbour's place have suggested to the mind of the beholder that he have something similar. The influence of environment, just now illustrated, is frequently observed also in the reflex action of the body upon the mind, and vice versa. The atmosphere or climate produces an impression upon the body, and this is reflected upon the mind. A malarious atmosphere poisons the blood, deranges the functions of the body, particularly of the liver; this physical condition reacts on the mind; and gloomy, despondent feelings are the result. On the other hand, a mental and physical exhilaration is felt in a dry, pure air and in bright, glowing, sunshine.

As the operations of machines supplant handicraft in various industries, and the machines become more and more automatic in their operation—become "standardized"—the labour becomes increasingly monotonous. Use of the same muscles and nerve centres fatigues and exhausts the worker much more quickly than if he had opportunity to obtain the relief which comes from variation in the work done. At the same time, the monotony is deadening mentally. "The worker knows only one process, and in this process there is little room for individual mentality, little opportunity for broadening his mental horizon."

For both body and mind a rest produced by change is needed. The heart beats about seventy-five times a minute, and is able to continue its work at this rate for perhaps eighty years, because after each rhythmic contraction of the auricles and ventricles there is a pause, a rest, of about the same length of time as is required for the double contraction. So in eighty years there are approximately forty years of rest.

The rate of speed of machines at which one is working may be as injurious to both mind and body, also, as monotonous toil. If the machines are run at what is termed a rhythm which differs from the natural rhythm of the worker, it causes strain on the nervous centres; if unduly continued, the strain may result in a complete breakdown. Moreover, the noises attendant upon machine operations, like noises anywhere, have wearing effects upon the nervous system, and tend to deplete one physically and mentally.

The fact that one's environment has an influence over his mind, is recognized by biographers. The scenery which a poet daily looked upon during the formative period of his life is often referred to as having been an important factor in determining the characteristics of his productions.

Art manifest in nature is the model for human art. The contrivances in nature suggest to man many of his greatest mental achievements and inventions. As men pattern after one another in building their houses, so those of keen insight pattern after the hints seen in nature—and so discover riches greater than "acres of diamonds." Mankind is under obligation to nature

for suggesting many of the finest poems which have been written. The influence of nature upon the mind of Bryant, for example, may be seen in many of his poems. In his "Inscription for the Entrance to a Wood," he says:

> Stranger, if thou hast learned a truth which needs
> No school of long experience, that the world
> Is full of guilt and misery, and hast seen
> Enough of all its sorrows, crimes and cares,
> To tire thee of it, enter this wild wood
> And view the haunts of Nature. The calm shade
> Shall bring a kindred calm, and the sweet breeze
> That makes the green leaves dance, shall waft a balm
> To thy sick heart.

"While wandering in the primæval forests, over the floor of which were scattered the gigantic trunks of fallen trees, mouldering for long years and suggesting an indefinitely remote antiquity, and where silent rivulets crept along through the carpet of dead leaves, the spoil of thousands of summers, that poem entitled 'Thanatopsis' was composed." In those imperishable lines the poet describes with matchless skill the influence of nature upon the mind.

> To him who in the love of Nature holds
> Communion with her visible forms, she speaks
> A various language; for his gayer hours
> She has a voice of gladness, and a smile
> And eloquence of beauty, and she glides
> Into his darker musings with a mild
> And healing sympathy that steals away
> Their sharpness ere he is aware.

Buckle argues at length to show the moulding influence of nature on the mind. He says: "The general

aspect of nature has, through the medium of the sight or other senses, directed the association of ideas, and hence in different countries has given rise to different habits of thought. Now, so far as natural phenomena are concerned, it is evident that whatever inspires feelings of terror, or of great wonder, and whatever excites in the mind an idea of the vague and uncontrollable, has a special tendency to influence the imagination, and bring under the lower and more deliberate operation of the understanding. The striking difference between India and Greece gave rise to corresponding differences in their mental associations. For, as all ideas must arise partly from what are called spontaneous operations in the mind, and partly from what is suggested to the mind by the external world, it was natural that so great an alteration in one of the causes should produce an alteration in one of the effects."

Von Humboldt, in one of the most profound passages in his *Physiognomy of Plants,* remarks: "Knowledge of the natural characters of different regions of the world is an essential part of the history of the human race and of its culture. For although the beginning of this culture is not determined by physical influences alone, yet its direction and national character, the gloomy or cheerful temper of mankind, depend largely on climatic influences. The sky of Greece had a great influence on its inhabitants. The poetry of the Greeks, and the ruder songs of the primitive people of the north, mainly owe their peculiar character to the forms of the plants and animals,

to the mountains and valleys which surrounded the poet, and to the air which he breathed."

This moulding and controlling influence of nature upon the mind is presented by Wordsworth thus:

> Nature can so inform
> The mind that is within us, so impress
> With quietness and beauty, and so feed
> With lofty thoughts, that neither evil tongues,
> Rash judgments, nor the sneers of selfish men,
> Nor greetings where no kindness is, nor all
> The dreary intercourse of daily life,
> Shall ere prevail against us, or disturb
> Our cheerful faith, that all which we behold
> Is full of blessing.

There is no other way in which nature has so clearly led to man's mental discipline as not only by her holding temptingly in her possession the necessities of life, such as food, clothing and shelter, but also by the liberal returns she makes for every exercise of the reasoning faculties. By the barriers she presents to him on every hand, she forces him through necessity to physical and mental exertions.

Whether man obtains his food from the chase or from agricultural pursuits, in either case he is rewarded according to the physical and mental skill which he displays. The larger returns obtainable from use of the arrowhead instead of the war club formed an inducement to further attempts at invention. Through the scarcity of animals and the increasing difficulty of obtaining food from them, man was driven to agriculture. Here scope for the exercise of his mental powers became larger, and the rewards were correspondingly increased.

The strongest minds are generally those that have had to surmount the greatest obstacles. Ease tends to ennui. New energies are called into action by those things which are regarded as natural evils. Necessity is truly the mother of invention. It was necessary for the Hollanders to combat the sea or drown; so they raised their dykes, and in so doing developed a determination, perseverance and skill which made other difficulties seem small to them. Such people are hard to conquer.

It looks as if it were intended that men are to

> Rise on stepping-stones
> Of their dead selves to higher things.

In the process of his development man has had meteorological phenomena from which to protect himself, the fauna to resist, the flora to overcome and render useful, the seasons to consider, deserts to irrigate, swamps to drain, rivers to span, lakes and seas to navigate and the secrets of nature to discover and utilize. He also has seen that his habitat did not produce all the things which were desirable. As such advantages could be obtained elsewhere, commerce was originated, and the desire for it led eventually to the development of every industry and even to the discovery of new worlds.

Thus we see that nature opposes, represses, diverts, directs, stimulates, and so develops, the mind of man. The processes of mental training began in bodily and productive labour, and it is this fact which has developed the mental powers and led to science and art.

III

THE INFLUENCE OF NATURE UPON MAN SPIRITUALLY

CONCERNING the influence of nature upon man spiritually, McCosh says: "We must allude to the Sublime, so far as natural objects are fitted to raise the feeling. Visible things can here do nothing more than aid the mind, which uses them merely to pass beyond them. The feeling of the Sublime is acknowledged on all hands to be intimately connected with the idea of the infinite. Everywhere in nature there are scenes which are

> Like an invitation in space
> Boundless, a guide into Eternity.

"Every display of power evokes this overawing sentiment; we see effects which are great, arguing a power which is greater. The howl of the tempest, the ceaseless lashing of the ocean, the roar of the waterfall, the crash of the avalanche, the growl of the thunder, the shaking of the very foundations on which we stand when the earth trembles—all these fill the imagination, but are suggestive of something more tremendous behind and beyond."

Peschel says: "The desert contributes materially to monotheism, because, from the dryness and clearness

of the atmosphere, it does not expose the senses to all the attractive phantoms of forest scenery. But if a sunny land is favourable to monotheistic emotions yet at the same time every religious creation is but the expression of the mental endowments of the race."

Professor Harris, in his *Self Revelation of God,* asserts: "Nature, in its unchanging principles, laws and types, expresses the unchanging thought of God. As nature reveals God, so God reveals nature; for we know the real significance of nature only as we know the infinite in the finite, the ideal in the physical, the God in nature. As the diamond reveals the light that continually falls on it, so the light reveals the diamond. The diamond would be little esteemed if estimated only by what is known of it in the darkness. God is the light of the world, and he knows little of the real significance of nature who knows it only as nature and without God."

Man finds that nature corresponds with his own inner life, his spirit. The winds and storms, the rainbow and sunsets, the rustle of the leaves and the very stillness awaken in him a consciousness that he is in the presence of spiritual forces; that great, incomprehensible power is all about him; that, in that All-Power he lives and moves and has his being. This Power he may worship as the Great Spirit, as did the American Indians, or as the Power behind nature, as did the Greeks, or as the benign and fructifying, life-giving influences in the sun, as in Magism, or in the dual forces everywhere manifest in nature, as did the Parsees.

Under numerous symbols God has been worshipped through the deified forces of nature, and this fact indicates most emphatically that nature influences man spiritually. Hence we conclude that he whose heart is in touch with nature,

> Takes no private road,
> But looks through nature up to nature's God.

Just how deeply man is thus influenced does not appear on the surface. We reserve this subject for consideration in another chapter, where its importance will be more fully brought out.

IV

THE INFLUENCE OF NATURE UPON MAN NOT ACCIDENTAL

THE threefold influence of nature upon man is no mere accident, but is designed by the Creator. All the laws and phenomena of the universe are but the expression and unfolding of His one eternal plan, and the influence of nature upon the body, soul and spirit of man is a part of that plan.

As Guyot states:

"Inorganic nature exists not only for itself but to serve as a basis for the life of the plant and the animal; and in their service it performs functions of a kind *greatly superior* to those assigned to it by the laws which are purely physical and chemical. It is correct to say that inorganic nature is made for organized nature, and the whole globe for man, as both are made for God, the origin and end of all things."[1]

Although LeBon, in his *Evolution of Forces,* is very far from championing the subject of design in nature, he, like nearly every other scientist, has to acknowledge thought and plan. He says:

"Even when we liken to physico-chemical forces the vital forces manifested by living beings, it must be

[1] *The Earth and Man,* p. 11.

recognized that things happen as if there existed quite peculiar forces, some of which are intended to regulate the functions of the organs, and others to direct that force. The regulating forces act as if they watched over the proper working of the living machine, regulating the temperature and the constancy of the composition of the blood and other secretions, limiting the oscillations of the different functions, adapting the organism to the changes of the outer world, etc. They hold undivided sway over the region of unconscious life which constitutes the greatly preponderant part of the existence of beings. The philosopher may deny their existence, but the physiologist, who sees them perpetually in action, hardly contests. He generally recognizes, like Claude Bernard, 'true directing principles which direct phenomena which they do not produce, and physical agents producing phenomena which they do not direct.'"[2]

In perfect accord with the above is the Report of the Committee of the American Chemical Society, published in 1923, which said:

"Our blood has a remarkable capacity to preserve its normal slight degree of alkalinity, to escape at the same time the Scylla of hyperacidity and the Charybdis of excessive alkalinity. This wonderful capacity for self-adjustment and preservation of its optimum conditions for the purpose of life is a typical instance of innumerable fine mechanisms of self-adjustment in the body, all aimed at maintaining the most favorable environment for the functioning and preservation of life—self-adjusting mechanisms which in fact comprise for the scientific investigator the most impressive points of difference between living organisms and the lifeless

[2] P. 367.

world. There are chemical 'buffers' present, which act chemically to preserve neutrality exactly as powerful springs act as mechanical buffers to minimize the shock of impact to fast-moving bodies."

"The Supreme could foresee that which was to come and which He had pre-ordained; the revelations of geology enable us to take a retrospective view. But they do more; they afford us the means of exercising a reflex faculty; we can examine the first figure in the vertebrate series, and from that point look down the long vistas which are opened, to the period when man appears as the final and foreseen product of the one mighty plan—the last in time, but the first in the contemplation of Him who called them into being. When man appears on the scene which had been so long prepared and, as it were, waiting for him, the consummation of the earthly type comes out. The eternal Logos—Himself in due time to become flesh—had contemplated all this from the beginning."[3]

Professor Simon Newcomb says:

"Should we see in visible masses of matter the same kind of motions which we know must take place among the molecules of matter as they arrange themselves into complex attitudes necessary to form the leaf of the plant, we should at once conclude they were under the direction of a living mind, who was superintending the execution of these arrangements."

"The realization of plan, which is thus universally seen in individual things, is also seen in the wider and ever wider combination and interplay of separate parts of the world. All things in nature, from atoms to constellations, fit into one another with the utmost nicety and work together without slip or jar in perfect smooth-

[3] McCosh, *Typical Forms,* pp. 331, 345.

ness. What a wide co-operation of forces plays about a blade of grass or a flower! The seed and soil and shower and sun, the rocky layers under the soil, down to the burning core of the earth, and all the stars in the sky,—mysterious physical, chemical and vital forces are all working together in exquisite harmony that that tiny blade of grass may grow, that that frail flower may bloom.

> Rings of wavelets on the water,
> Circling flights of butterflies,
> Interweave themselves with orbits
> Of the planets in the skies." [4]

The plan of the Creator is so apparent that Buffon says: "Nature is the visible throne of the Divine power. Created to be a spectator of the universe, and a witness of its wonders, the divine spark by which man is animated renders him a participant in the divine mysteries. He sees and reads in the book of the world a reflection of the Divinity." [5]

In the words of Sir Oliver Lodge: "The ages of the earth's past seem to have been a sort of preparation for the life and mind which now is, and for the mind which is to come. By faith we feel bound to suppose that there is some far-seeing Design, some lofty meaning in it all, and that the ultimate outcome will be worth while. Depend upon it, nothing is haphazard, things are not left to chance. Everything points to rational Plan, of which we know neither the beginning nor the end." [6]

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[4] Dr. J. H. Snowden, *The World a Spiritual System,* p. 143.
[5] DeLanoye's *Sublime in Nature,* p. viii.
[6] In *Scientific American,* August, 1925.

Law reigns universally. The possibility of science depends upon this truth. Hence, there can be no accidents; the influence of nature upon man must have been designed by the Creator. Thus nature becomes the thought of God, and science is only the study of His divine operations in matter and mind.

Concerning this conclusion Professor Agassiz says: "There is behind the works of God, and anterior to their existence, a thought. Whenever we study the general relations of animals, we study the manner in which it has pleased the Creator to express His thoughts. Museums should be no longer considered as libraries of the works of nature but as libraries of the works of God, in which we read His thoughts."

Browning expresses it thus:

> Every natural flower which grows on earth
> Implies a flower upon the spiritual side,
> Substantial, archetypal.

Every sparrow and every flower, because it is His work, reveals in itself the thought and power of God, as truly as do those transcendent and isolated facts in the Supernatural which we call miracles. So far as man is concerned, moreover, every living thing is a miracle, and it would be so regarded if living creatures were not so common. For man is no more capable of understanding or creating a tiny speck of living matter, or protoplasm, than of creating a sparrow or an elephant. He can analyze it, separate it into its component parts and tell just how many atoms of hydrogen, carbon, nitrogen, oxygen, iron, and so on, its cells

contain. But though he can thus tear it down, he cannot reconstruct it; and never will he be able to do so—notwithstanding the fact that every little while some biologist or chemist rashly permits himself to be interviewed by a press representative, and then lets it be announced to the world that the great man has succeeded in combining all the elements in protoplasm, and that in his laboratory he is on the point of creating life itself. As a matter of fact, he can create a man—or an angel—quite as readily as he can one tiny cell of living protoplasm; and this he doubtless realizes, if he be a real scientist.

Those microscopic cells which are so extremely minute that their diameter hardly exceeds some thousandths of a millimetre have a marvellously complicated structure and properties even more complex. Their structure can be observed by the microscope, but the most wonderful thing about them is utterly invisible. They contain the germ of ancestral forms and hereditary traits of those yet to be born. What these tiny creatures are able to perform makes the skill and wisdom of the greatest scientist seem Lilliputian indeed. By means which we do not even suspect, the vital cells construct their complicated and varied compounds—the albuminoids, cellulose, fats, starch, etc., necessary to the support of life. They are able to decompose the most stable bodies, such as chloride of sodium, to extract the nitrogen from the ammoniacal salts, and phosphorus from the phosphates, etc.

"All these labours.—so exact and so admirably adapted towards one end and directed by forces of which

we have no idea, and which behave exactly as if they possessed a second sight far superior to our reason—that which they are accomplishing, every instant of our existence, soars far above all that the most advanced science can realize. The scholar capable of solving by his intelligence the problems solved every moment by the cells of the lowest creature would be so much higher than other men that he might be considered by them as a god."[7]

Here, in the protoplasmic cell, we are in the presence of the thought and power of God. This is His territory. Here He is within every burning bush, and here all ground is holy ground.

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[7] *The Evolution of Forces,* LeBon, p. 363.

V

IN CREATION MAN'S HIGHEST NEEDS WERE UPPERMOST IN THE MIND OF GOD

THE wisdom and benevolence of God would certainly lead us to such a conclusion as this. He knows where real values lie. They are not in size but in quality. A single being made in the image of God, made capable of knowing, loving and fellowshipping his Author, outweighs in importance the billion or more suns in the universe.

Tennyson has beautifully summarized the thought:

> For tho' the Giant Ages heave the hill
> And break the shore, and evermore
> Make and break, and work their will—
> Tho' world on world in myriad myriads roll
> Round us, each with different powers,
> And other forms of life than ours,
> What know we greater than the soul?

In the Scriptures the redemption of the race is the one central fact toward which all lines of truth converge. And since they also teach that the Redeemer is the Creator of the universe, and that "without him was not anything made that was made," we may safely affirm that what was the chief thought in God's mind as Redeemer must have been in His mind as Creator also. Hence, we might expect to find, and we do find,

that the facts in nature, like those in the Bible, ever point toward man and his highest or spiritual needs. Nature is progressive in its development. In the lowest forms of life we see the promise and potency of something higher. Like early types in the Bible, lower life forms foreshadow better things to come.

President McCosh, in his *Typical Forms,* shows that all nature is formed on an elaborate system of types. Geology, in every age, reveals a typical system, which is also a system of prophecy, in which the past ever points to the future and the future appears as the fulfilled prediction of the past.

The cell is a typical element in the structure of plant life, as truly as the atom is a type in the structure of the solar system and of the universe. In its lowest forms, the plant consists of separate and independent cells; and in its highest forms, it is built up of the same material combined in various ways.

The lowest animals form a prophecy of the higher, and the higher, a prediction of man. In describing the structure of the human brain, Hugh Miller says: "Nature first lays down a grooved cord, as the carpenter lays down the keel of his vessel; and on this narrow base the perfect brain, as month after month passes by, is gradually built up, like the vessel from the keel. It first grows into a brain closely resembling that of a fish; a few additions more impart the perfect appearance of the brain of a bird; it then develops into the brain exceedingly like that of a mammiferous quadruped; and finally, expanding atop, and spreading out in deeply corrugated lobes till they project widely

over the base, it assumes its unique character as a human brain. Radically such at the first, it passes through all the inferior forms, from that of the fish upwards, as if each man were in himself not the microcosm of the old fanciful philosophy, but something greatly more wonderful—a compendium of all animated nature and akin to every creature that lives. Hence the remark, that man is the sum-total of all the animals, 'the animal equivalent,' says Oken, 'to the whole animal kingdom.'"

"It may be safely said that to the rational spirit of man, with all his spiritual faculties and susceptibilities awake, the physical system *in itself* presents no worthy end for its existence, no end which can meet and satisfy the demands of reason and the spiritual life." So says Harris. "We infer, therefore, that the physical system as a whole exists not for itself, but as subservient to the bringing in of the spiritual system, and of man as belonging to it." This reminds us of the remark of Sir Oliver Lodge, "By faith we feel bound to suppose that there is some far-seeing Design, some lofty meaning in it all, and that the ultimate outcome will be worth while."

The same idea, but carried further, is presented by McCosh thus: "The simplest organism points by its structure upward to man, and man's earthly frame points to his heavenly frame, and his heavenly points to Christ's spiritual body—and we see that all animated things on earth point onward to his Glorified Humanity as the grand archetype of all that has life."

As the processes of nature have gone on, there has

been more and more an unfolding of the Redeemer's plan and purpose, which run through all His works and culminate, as far as man is concerned, in the quickening and development of man's spiritual nature. Toward this end all nature points, and for the accomplishment of this all her works co-operate, as we shall see.

First. One of the ways in which nature fulfils the purpose for which she was created is by exciting in man a desire for physical, intellectual and spiritual food.

Nature produces a peculiarly indefinite sensation of craving in the stomach for food, a sensation which we call hunger. The pleasure derived from eating, if brought vividly to mind, has a tendency to augment this sensation. The appetite is increased also by tempting sights and odours of food. The pain, suffering and weakness experienced from a lack of food act as goads to the desire to appease the hunger.

Nature awakens in the mind, also, a desire for knowledge. Instinct leads young creatures to exercise their functions even from the first. A kitten will watch for its prey and spring forward, as if upon it, when no prey is near. A young bird will scratch and pick and collect materials, as if to build a nest. Similarly, a child exhibits natural tendencies for intellectual food. It begins when still very young to pull things to pieces, to tear and destroy; and in numerous other ways it shows its inquisitiveness, which is a manifestation of the instinctive desire for knowledge.

The author of the *Key of Creeds* says that he him-

self has had, and that it is not unusual for other persons to have, such intense longing to know the secrets of the universe as to feel almost irresistibly prompted to hasten the termination of life in order to penetrate, unrestricted by the limitations of sense, the world that lies beyond.

The pleasure which is derived from discovery tempts to further efforts to satisfy the craving of the mind. The numerous objects upon every hand which arouse the curiosity and court investigation stimulate the desire for knowledge. The pain and privation experienced because of a lack of knowledge arouse desires for its acquisition and a willingness to put forth the requisite efforts for its attainment.

Nature awakens in us a desire not only for physical and intellectual food, but also for spiritual food. As an infant may not always be aware that its peculiar craving is the cry of its physical system for food, so man may not know that his restless, unsatisfied feeling is the cry of his spirit for nourishment. But the one is as actual and as reasonable as the other. There is hungering of the spirit for communion with the Father of spirits, whether He be the known or an unknown God. The longing for communion with the Deity is often so intense that a large part of mankind spend their time in little else than in efforts to satisfy it. The spirit of man will worship something—if not God, then mystery, man, money, power or natural objects.

There is no other pleasure so great, or satisfaction so perfect, as that experienced from worship. The pleasures and satisfactions derived from worship act

as a stimulant to further devotions. Upon every hand, also, there are phenomena which awaken religious emotions. The sublime in nature leads to awe and reverence. The beautiful sunset, a thunder storm, the roar of a waterfall, mysteries and death, arouse and quicken religious feelings. The sensations experienced by hearing a distant church bell on a quiet Sabbath morning are akin to those aroused by a sight of Fujiyama in Japan or the Ganges in India, Mecca in Arabia or the reputed Holy Sepulchre in Palestine.

Second. Nature not only awakens desire for, but is capable of supplying man with, physical, intellectual and spiritual food. A sufficient supply for every physical need is to be found in nature; and the half-open doors she presents to the mind upon every hand are entrances into her secret treasure house filled with that which is a delight to the seeker after knowledge. And in the very act of her satisfying the mind of the seeker after her ways she imparts an insatiable desire to know more of her mysteries. But she does more; she speaks to his spirit of, and leads to, the Father of spirits.

Even those things in nature which are the least attractive can exercise a healthful influence over our spirits. The fires of suffering purify and strengthen the moral and spiritual character. Disappointments and deaths, sickness and sorrow, pain and poverty draw out our moral aspirations and develop our religious purposes.

All the religions of the ancient world had nature for

a basis, and this development probably had its origin in the fact—a truth taught in the Bible—that nature reveals God. When man's knowledge of God began to grow dim his conception of the unity of God and the unity of nature likewise became weakened, and he began to see a divinity in each separate part of nature; so polytheism and nature worship resulted. "If there were good men," says Emerson, "there never would be this rapture in nature. If the king is in the palace, nobody looks at the walls. It is when he is gone, and the house is filled with grooms and gazers, that we turn from the people, to find relief in the majestic men that are suggested by the pictures and the architecture." But it is a point worthy of observation that nature religions would not have originated had not nature spoken to man a divine message. The fault is not hers that her teachings are so often misunderstood; the misconception is rather a result of a superficial observation of her works.

He who looks deeply into nature's secrets should be the last to lose sight of her unity and uniformity and hence of the unity and intelligence of her Author. President Hitchcock says: "How entirely have the natural tendencies of science been misunderstood, when they have been represented as leading to religious scepticism! I contend that scientific truth, illustrating as it does the divine character, plans and government, ought to fan and feed the flame of piety in the hearts of its cultivators. He, therefore, who knows the most about science ought most powerfully to feel this religious influence. He ought to go forth

from it among his fellow-men with radiant glory in his face, like Moses from the holy mount." [1]

Professor Robert A. Millikan, in his *Science and Life,* is no less emphatic along the same line: "The first fact which seems to me altogether obvious and undisputed by thoughtful men is that there is actually no conflict whatever between science and religion, when each is correctly understood." He refers to Newton, Faraday, Maxwell, Kelvin and Lord Raleigh as the greatest names in the world of science: "No more earnest seekers after truth, no intellects with more penetrating vision, can be found anywhere, at any time, than these; and yet every one of them has been a devout follower of religion."

Lord Kelvin asserted: "I believe that the more thoroughly science is studied, the further does it take us from anything comparable with atheism." And again, later: "If you think strongly enough, you will be forced by science to the belief in God, which is the foundation of all religion."

Of Louis Pasteur, who was the peer of any biologist who ever lived, his biographer says: "Finally, let it be remembered that Pasteur was a deeply religious man." Over his tomb in the Institute Pasteur are inscribed these words of his: "Happy is he who carries a God within him, an ideal of beauty to which he is obedient—an ideal of art, an ideal of fatherland, an ideal of the virtues of the Gospel."

The ability of nature to satisfy the longings of the

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[1] *Religion of Geology,* p. 508.

spirit of man is presented by Ruskin thus: "There is religion in everything around us—a calm and holy religion in the unbreathing things of Nature. It is a meek and blessed influence, stealing in, as it were, unawares upon the heart; it comes quietly and without excitement . . . fresh from the hands of its Author, glowing from the immediate presence of the Great Spirit."

But nature can satisfy the longings of the spirit of man only by leading beyond herself to the Great Father of spirits.

Third. The spirit of man can be nourished only by spiritual food. But we have shown that nature feeds the spirit of man; hence, she must be spiritual. And if this be true, it is spiritual law which governs in the natural world, and not natural law which reigns in the spiritual world. This we believe to be the case. Spiritual force seizes upon the atoms of matter and combines them into desirable forms, and when these have accomplished the objects for which they were wrought upon, the spiritual force returns laden with its results to the God who gave it. By an invisible spiritual force, the atoms of matter are brought together to form an apple. The particles composing this fruit enter into the stomach of a hungry man and awaken in him feelings of gratitude, which ascend to

> That God, which ever lives and loves,
> One God, one law, one element.

In the example given above it is not alleged that nature imparts gratitude directly to the spirit of the

hungry man, but that her fruit is seen to be the bountiful provision for physical needs, and so suggests to the mind feelings of gratitude. This is the way in which nature ever draws out and develops man's spiritual life. Hence we see—

Fourth. Through nature man's spiritual food is supplied to his spirit symbolically. We have already shown that nature expresses the thought of God; that He designed that she should awaken desires in our body, soul and spirit, and then supply their needs by leading us beyond nature to Himself. Hence, all the objects of nature are symbols and types of spiritual truth, and the visible world is but the image of the heavenly world. Whatever comes to the spirit of man through nature must come symbolically.

The symbolical character of nature is indicated by the fact that it can be apprehended by the mind in ideas, as the intellectual equivalents of nature's operations. Material things express the thought of the Creator, as the engine expresses the thought of its maker or as written words express the thoughts of the writer.

"The Chambered Nautilus" is a beautiful symbol of how our life should expand:

> Thanks for the heavenly message brought by thee
> Child of the wandering sea,
> Cast from her lap forlorn!
> Build thee more stately mansions, O my soul!

Falling leaves, as symbols, speak to us of the end of our earthly life. The divine Spirit is expressing His

archetypal thoughts in the physical universe—God's first revelation, the first Bible. It is the primer, the first lesson in which He intends us to spell out His name, and to read His nature and will. Flowers show us that their Author is endowed with the sense of the beautiful, and wants us to be like them.

Fifth. Likewise, in His higher revelation, the Bible, God speaks to us in a language of symbols. For all language is symbolic. Only through things can thoughts be expressed. Signs and their combination into language represent thought. They never, however, express thought perfectly. For this reason, thought which is revealed through spoken language accompanied by other symbols, such as the expression of the face, gestures, tone of voice, etc., is more easily understood, and hence more greatly enjoyed, than the same thought revealed only through the symbols of language.

The symbols employed in the expression and interpretation of thought are more numerous than is usually considered. The sense of touch plays an important part as a symbol in the revelation of thought. Many years ago Laura Bridgeman, as a result of scarlet fever in infancy, was deprived of the senses of sight, hearing and speech. Yet through the sense of touch, like Helen Keller she was able to acquire an astonishing amount of knowledge. It was said of her that passing along the hallway, in the institution which was her home, she recognized everybody, and gave them greeting in her own way. After shaking hands with a person only once, she was able to recognize that

person after the lapse of even six months. Elihu Burritt says of her: "They went to work to educate the sense of feeling to the nicest susceptibilities. They made a wooden alphabet, wooden models of ideas, of things that had been, are and shall be in the world. And these she touched most thoughtfully, as if listening to the music of a new existence; and, wonderful! her finger ends became endowed with faculties almost miraculous, and filled her mind with astonishing revelations of things present, past and to come."

Through the symbol of touch, the thoughts of centuries past were conveyed into Laura Bridgeman's dark mind. In a similar manner, through the Bible, by means of symbols which are models of ideas, God has presented to us His thoughts.

Sixth. In nature God speaks to us in symbols of His own creation, but in the Bible it is chiefly through symbols of our invention. The symbols of the former are not arbitrary, but those of the latter are purely so, like the symbols of algebra. The letter *S* is an arbitrary symbol of a certain sound, which might as well have been represented by any other character, as indeed is done in other languages. Again, this symbol, in combination with three other equally arbitrary symbols, has come by common consent to mean the word *soul,* which represents something entirely different from any of these four letters. The word might just as appropriately signify boot as soul, except for our arbitrary custom.

Hence, we see that in language we employ a triple combination of artificial symbols. Certain particular

marks represent a letter, and this represents a particular sound, and the letter combined with other letters represents a particular thought.

Language is frequently clarified by other symbols which approach nearer to nature. This is probably the reason for our enjoyment of poetry. Almost every line teems with types which explain the world. In the Bible, then, God speaks to us by means of the arbitrary symbols of our own language.

The more general the consent as to the use of certain symbols in a language, the more widely the truth can be disseminated by that language. Also, the more nearly the symbols of a language approach to those which would be suggested to all minds, the better the facilities it affords as a vehicle of thought. Thus the symbols in nature approach more nearly to gaining the universal consent of mankind, as representatives of thought, than it is possible for any one human language. For example, a frown on the face is universally regarded as indicating displeasure. A flushed face, gleaming eyes, smiles and tears are plainly the language of feeling, which everybody understands.

The Bible being for all mankind, in it God expresses His truth not only in arbitrary symbols of language, but also in types, pictures, parables, the natural relation of parents to children, and the like. All these make clearer the meaning of the arbitrary symbols in the human language used.

Nature's symbols are not arbitrary. Whatever they express of thought is in accordance with the minds of all men. Flowers are recognized everywhere as beau-

tiful and as appropriately representing the beauty in the mind of the Creator. To use some hideous monster, like the devil-fish, to express thoughts of beauty, would be employing an arbitrary symbol, however; only to those who had agreed that it should represent beauty would it suggest any such thought. But flowers, when presented to the sight, are recognized immediately as proper symbols of the beautiful.

So it is in all others of God's works. There is in them all a fitness to express the thoughts that lie back of them, just as there is a natural fitness in the parables which Christ used to make clear the spiritual truths in His teachings. Jesus' symbols are not arbitrarily chosen, any more than are the types in the Old Testament. In Christ's teachings it is not exactly that one thing is used to make other things intelligible; there is a divine harmony between the natural thing chosen by Him and the spiritual truth to be imparted, and hence the natural phenomena used by Him became a kind of proof of the spiritual facts revealed.

Without doubt, however, God speaks to us in ways which lie deeper than nature, and beyond the symbols of the language read; directly, telepathically, by the sight of passages previously read, by sounds heard at former times, by the association of ideas—by the inductive method, causing things known to lead to the hitherto unknown. Many devout people believe this direct speech of God to be fully as important a method of divine communication as the printed words. It is sometimes called the "inner light."

Seventh. From what has been said it will be seen that the revelations in nature and in the Bible must harmonize. They are both from the same Author and find their unity through their common relation to Him. They both exist to reveal Him and are the expressions of His thoughts.

The Bible is God's "Old Testament," and nature is His older testament; and it is as impossible that there should be discord between them as that there should be discord in the mind and character of God Himself. As there is unity in Him, there must be unity in the revelations which He makes of Himself.

The Duke of Argyll remarks: "We are perpetually reminded that the laws of the spiritual world are, in the highest sense, the laws of nature, whose obligation, operation and effect are all in the constitution and course of things."

And this is the truth which Drummond, in his *Natural Law in the Spiritual World,* has endeavoured to prove and illustrate. He states: "It is almost singular that the identification of the Laws of the Spiritual World, with the Laws of Nature, should so long have escaped recognition. Phenomena are parallel, Laws which made them so are themselves one."

The Bible fits us. It speaks to us of what we know—and yet we did not know it until we found it expressed there. It seems almost like an *imprint* of the impression which God made when He created human nature. When we read and ponder the Bible, it has the curious effect of making us feel as if it were made up of leaves from our own personal experiences.

It reads us to ourselves. It meets us in nature, and leads us beyond nature.

The Bible and nature have frequently been made to disagree, to be sure, but it was because of a misinterpretation of one or both of these books of God. All lines of truth in both originate in Him and, when followed to their termination, are seen to end in Him.

Eighth. The one book of God illustrates the other. The whole sacrificial system of the Old Testament is the making use of nature to explain spiritual truth. Jesus employed the same method in His teachings. This was imparting instruction by what has come to be called the scientific, inductive method, a passing to the unknown by means of the known, through exact observation of the facts, a correct interpretation and rational explanation of them, followed by an orderly construction of them, so that they are seen to agree with the realities.

If it were possible to obliterate from the Bible every allusion to nature, and every truth clarified by the use of natural phenomena, there would be little left to us; and what remained would be so unintelligible that a further revelation would be necessary to interpret it. The remnant would be hard, bare truth, a mere skeleton of the original, with the flesh and blood and glow of life gone.

But nature and the Bible were joined together by the Divine hand; what God has joined together, let not man put asunder. Indeed, it is impossible for man to divorce them; they are one and inseparable.

Nature furnishes food for man's body, soul and

spirit in the order in which they are named. This truth we have already presented in our discussion of the progress in creation and of the formation of the Scriptures. In both there is an ascension from type to type, till the spirit of man is reached, redeemed and typically glorified in the resurrection life of Christ.

Nature is the base, as of a pyramid, of God's higher spiritual revelations in the Bible and in Christ. Concerning the basis which nature forms for the Divine revelation in the Scriptures, Trench states: "Besides His revelation in words, God has another and an older; and one, indeed, without which it is inconceivable how the other could be made, for from this it appropriates all its signs of communication."

As illustrating the manner in which nature is the basis for the revelations in the Bible and in Christ, F. Oswald Dykes tells us: "The actual revelation recorded in the Bible employed nature as its organ. In the revelation of new truth God is constantly found availing Himself of the old creation. Dreams and visions and voices to the ear, the thunder-cloud on Sinai, the cleft sea, death and the plague, the vicissitudes of war, conquest and revolt, were all turned into vehicles for teaching saving lessons to mankind. The whole of Bible teaching, too, attaches itself to the parables of nature. Domestic and social life, the farm, the fishery, the garden, are inspired with deeper thoughts than they naturally utter.

"God makes nature vocal in the redemption. Above all, His final revelation of Himself is in the nature of man; a true natural life resting on the physical basis

of a true body, 'born of a woman;' so that the highest of all revelations is in appearance the most human, the least supernatural. Now, how could all this be? How could the new revelation utilize the old creation and make earth and sun and sky—above all, man himself—its ministers to preach salvation, unless, first of all, creation were itself full of God, and yet were after all, God's servant to work withal? "

Ninth. Nature and the Bible are related to each other as is the general to the particular. Hence, though nature includes the Bible, the Bible does not include nature; it includes a small portion of nature. For this reason nature can explain and illustrate the truth of the Bible, though the Bible cannot teach nature. Facts and experiences which are known to be common to all men may illustrate and explain those of a particular man, but the facts and experiences of any particular man may or may not illustrate and explain those of all men.

An erroneous conception of the nature and purpose of God's revelation in the Bible has frequently led into groundless criticism regarding its silence on scientific and other interesting subjects.

" One can but be struck," says Dr. Storrs in his *Divine Origin of Christianity,* " by the surprising and apparently prearranged silences which mark the Christian Scriptures; silences upon themes which with constant force attract our attention; silences which seem actually a part of the marvellous purpose and plan of the Scriptures, as are the vacant spaces in walls, through which the households dwelling behind them

look out on landscapes or distant skies." We should be no more disturbed that the Bible does not teach science, than we are that spherical astronomy does not teach the arithmetic on which it is based.

The Bible is the history of God's dealing with man for the purpose of redeeming him from sin. It reveals God to man, and man to himself. The long vistas of the past, " before the world was," are included in the urge of the plan to release man from sin, sickness and death, and to incorporate him into the wholeness of the divine nature, through his union with Christ Jesus. The Bible is the drama of man's sin and salvation. As the curtain rises, we see man fleeing from a holy God, because of the shame and sting of sin in his own soul. In the closing scene we behold him seated on a throne, sharing the glory of the " Man crucified " and, like Him, radiating the purity, glory and love of God.

VI

NATURE ILLUSTRATIONS AND EXPLANATIONS OF BIBLE TRUTHS

THERE are many things in nature which illustrate and explain the spiritual truths taught in the Bible, though less clearly, in the same manner in which the general teaches the particular. We now consider a few of these.

First. The Bible everywhere represents to us God as our Father, and Jesus taught that in prayer we should address Him thus. But this term has comparatively little influence on the mind till one has become a parent himself. But when one sees his own infant child devoid of knowledge and utterly helpless, his heart goes out with self-sacrificing love for the little one, who does not even so much as know his father, and who cannot appreciate his affection. At such a time the revelation in the Bible of God as our Father in heaven becomes more real; ever after it has new meanings.

Paul in his address at Athens reminds his auditors that their own scripturally unenlightened poet, Aratus, had said: " For we are also his offspring," thus indicating that the parental relation naturally suggests to the mind the relation which we bear to the Deity, and confirms and explains that truth as taught in the Bible.

Second. Certain passages of Scripture speak of

stones as receiving impressions from the human voice, as being witnesses to transactions and as capable of yielding up their evidence, or of speaking. For example, Joshua 24:27: "Behold, this stone shall be a witness unto us, for it hath heard all the words of the Lord which he spake unto us." Or Habbakuk 2:11: "The stone shall cry out of the wall, and the beam out of the timber shall answer it." Jesus Himself said: "If these should hold their peace, the stones would immediately cry out" (Luke 19:40).

It is known that the human brain and mind are exceedingly sensitive to impressions, even the most delicate. So true is this, that many psychologists maintain that we never entirely forget any impression made upon us through either sight or hearing. This truth is confirmed by the experience of many persons who, when they had thought they were drowning, or had received a shock which threatened death, saw thoughts, scenes and experiences of past years which were either wholly forgotten or perhaps never remembered at all, rush into the mind in an instant of time, and beheld them as one vast panorama.

The present writer had a friend, a trained nurse, of more than ordinary intelligence and training, who, when she was about to become unconscious under anæsthetic prior to an operation, repeated accurately a prayer written by Robert Louis Stevenson, though she had never committed it to memory and had had no realization that she knew it. When told of the occurrence she remembered that she had read it and had been impressed by its beauty.

Numerous similar examples might be given. Coleridge in his *Biographia Literaria* mentions the case of a German minister who was accustomed to read and recite aloud passages from Greek, Rabbinical Hebrew and Latin authors. A young, uneducated maid in the family overheard him doing so. Many years afterward when she was in insane paroxysms she was heard to repeat accurately many such passages, though otherwise she knew not a word in any of those languages.

Surely we ourselves physically and mentally are a book, in which are being indelibly inscribed, though possibly illegibly for the present, all the facts and experiences of our lives.

Science teaches not only that the brain and mind are thus delicately sensitive to impressions but that all things are equally so.

Ever since the days of Volta, and by his discovery in 1797, it has been known that a piece of zinc cannot touch a piece of copper without producing a spontaneous electric charge in both metals, the zinc being charged positively and the copper negatively. Similar phenomena in a measure not only characterize all metals, but are practically universal. The most delicate waves of heat cannot fall upon a piece of metal without causing an electric current to move toward the cooler portion of the metal. It is impossible to touch a bit of matter anywhere without electricity and heat being manifested.

The teaching of science is that we are leaving impressions of our words, actions and thoughts upon the

universe as plainly and as indelibly as if we were chiselling them with steel in granite rock.

It is a rather common experience to speak into a microphone and have the faintest sounds recorded and later hear these reproduced at will. In a similar way, one now can speak into a microphone and cause the sounds of the voice to be transformed into ether waves which speed forth on a never-ending journey. In the telegraphone, also, our speech, with all of its inflections—the delicate whisper as well as the clear tone—is magnetically and indefinitely impressed in a steel disk, or on a steel wire, and at our will the instrument is made to reveal in distinct tones, all that which may have been thus sung, said or whispered. But, just as certainly, sound waves make an impression upon everything with which they come into contact.

If, then, we are able to make a piece of steel hear what we say, and later to call upon it to bear witness, in our very original tones, to what we said, scientifically it is not at all impossible for stones and other objects to be similar witnesses. The ancient prophet's declaration that the stones had heard the word of the Lord or the assertion that a stone was to cry out of a wall were more than figures of speech. Under certain conditions which we already understand, such statements could be proved as most scientifically accurate.

It is true, also, that we register ourselves not only upon our own immediate environment but upon the entire universe. If we are not able at present to reproduce all the sounds and sights which we leave upon nature, our failure is due to our lack of suf-

ficiently delicate apparatus and to the dullness of our senses of sight and hearing.

The impact of the molecules in sound waves results in heating them to a higher temperature; then, as waves of heat and light, they speed to the farthest bounds of the universe at the rate of about 186,300 miles a second. The sound vibrations roam about the solar system for 400 years before they reach its limits, and in all their journeying they make as actual an impression on all the worlds as they made upon our tympanic membranes when first they started out.

It is a matter of common observation that heat produces effects upon all bodies. The thermometer shows that bodies dilate with heat and contract with cold. The sensitiveness of matter is such that the variation of one hundred millionth of a degree can be detected and registered by Langley's bolometer. The slightest oscillation in the ether causes the particles of matter to vibrate and radiate, and hence there is a continuous exchange of energy between matter and the ether.

Our bodies and their every movement are thus transmitting energy to the ether, in it to move with the speed of light in every conceivable direction. The rays of light falling upon us and reflected from us carry away countless numbers of images, so that millions of photographs might be taken of us almost at once, were there cameras placed in so many positions. These perfect pictures of us and of our acts are being ceaselessly carried into space. Travelling at the rate of 186,300 miles a second, they will not reach the

nearest neighbour to our solar system, Alpha Centauri, in four years; the bright star Sirius, the third nearest, in eight years; Regel in Orion, in about 500 years; or the Island Universes in the Nebulæ in Andromeda, in one million years.

Recently there was brought to the writer's attention the case of a woman who, standing in her dooryard one morning, was astonished to hear the voice of a man giving orders over the radio to his calisthenic class. There were no radio receiving instruments about, but high tension electric wires ran over the place. The ether waves carrying the man's voice fell upon those wires and in some mysterious way were transformed into sound waves, and these were heard by the woman.

Those calisthenic directions were carried onward toward Regel—on which they will arrive in about 500 years. On their million year journey they will be accompanied by our most casual words and acts. Indeed, a few thousand years hence we ourselves may be there, and be able to listen to them as they come in, freighted with all our past history.

Such scientific facts as we have considered illustrate and enforce the teaching in the passages of Scripture given above.

Third. The Bible has numerous passages which refer to the praise or the singing of nature. Isaiah 14:7: "The whole earth breaks forth into singing;" chapter 35:2: "The desert shall blossom abundantly and rejoice even with joy and singing;" chapter 55:12: "The mountains and hills shall break forth before you

into singing." I Chronicles 16:33: "Then shall the trees of the wood sing at the presence of Jehovah." Psalm 65:13: "The pastures are clothed with flocks . . . they shout for joy, they also sing."

These statements are something more than mere poetic expressions or beautiful figures of speech. They are in perfect accord with the facts of science. The air is constituted with rhythmic properties. Nature is full of music. The atmosphere is likely to originate it, as vibrating winds sweep around the corners of houses making whistling tones, or as tornadoes charge among the forest trees or roll through the gorge—all analogous to the vibrations of air through organ pipes.

Water produces musical sounds as it falls over the cataract or rushes down the mountain or around the river banks, among the bushes or, in the brook, over the pebbles. We speak very appropriately of the warbling brook singing its way to the sea.

Professor John Tyndall calls our attention to the fact that the waves of the sea are derived from the winds, which are in their turn derived from the sun; water waves are nothing more than heaped-up motion of the ether waves. It is the calorific waves emitted by the sun which heat our air, producing our winds and hence agitating our ocean. "And whether they break in foam upon the shore or rub silently against the ocean's bed or subside by the mutual friction of their own parts, the sea waves, which cannot subside without producing heat, finally resolve themselves into waves of ether, thus regenerating the motion from which their temporary existence was derived."

The musical tones produced by commingling waters are, doubtless, one reason why we enjoy sitting for hours by the seashore dreamily listening to the ceaseless cadence. The rhythmic motions of the water and the ebb and flow of the tides leave geometric patterns on the sand which are similar to those produced by musical tones in sand or other soft yielding substances. These are termed the figures of Chladni, after their discoverer. We shall refer more at length to them later.

All substances, in a greater or less degree, have the same properties that are possessed by the wood, metal or membrane of which musical instruments are composed. They vibrate in exact harmony with the waves of air which sweep over them, their very atoms being melodious. The notes emitted by a single vibrating string or wire in themselves constitute quite an orchestra. They do not consist of waves of uniform length but are a highly complex combination of many series of waves of different amplitudes. The string or wire vibrates not only as a whole but in segments; and its halves, thirds, fourths, and so on, vibrate separately, producing "overtones;" and these give individuality, colour and character to the tones of different instruments.

Concerning these "overtones," Edwards, in his *God and Music,* says: "Without these spirit-like attendants of musical notes, all voices and instruments would have the same quality, becoming monotonous and insipid. Ministering spirits of viewless sound, they furnish the endless varied colouring of music."

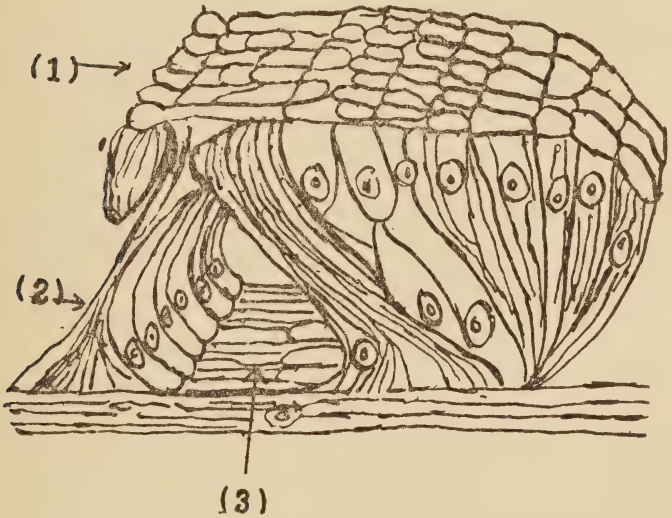
Who has not witnessed particles of dust dancing in a sunbeam? The sun heats the air, causing it to vibrate, and the dust, becoming visible because of the reflection of the light from it, is seen vibrating with the air. That is what is continually occurring not only in the air but in everything else about us.

Nature at its very heart is musical. The xylophone may be made of parallel bars of wood or stone, graduated in length; each stone or piece of wood has its own individual pitch or rate of vibration. Many similar musical instruments can be constructed, as from tumblers, bells and the like. These not only vibrate as a whole but their atoms have their keynote also.

Professor Silliman, in his *Principles of Physics,* remarks that " the aggregate sound of nature, as heard in the roar of a distant city or in the waving foliage of a large forest, is said to be a single definite tone of appreciable pitch. This tone is held to be middle F of the pianoforte, which therefore may be considered the keynote of nature." It is worthy of note, also, that our F corresponds with the Chinese " Kung," which Ling Lun, an early scholar, recognized as the root tone of nature. The waters of the Hoang-ho rushing by intoned " Kung," and Ling Lun's own voice, when speaking, was in unison with it; hence " Kung " was symbolical of the earth among the elements.

The ear is constructed on the principle of a delicate musical instrument. Indeed, no musical instrument which man ever has invented can approach this wonderful contrivance by which we are made cognizant of the exterior world. Our grand pianos compass about

seven and one-half octaves of musical sounds, have about 220 wires each and are so large that several men are needed to transport one of them. But in the tiny ear, within the compass of a cubic inch or less, there is a lute capable of responding to twelve octaves of sound waves. More surprising still, in the inner ear—in the



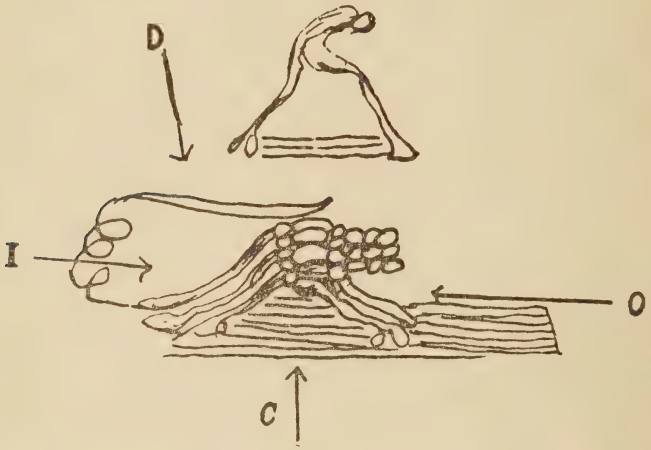
A PORTION OF THE ORGAN OF CORTI, GREATLY MAGNIFIED

(1) Auditory cells. (2) Internal rods, or cords, 6,000 of these. (3) Bacillary strands, or cords, in the organ of Corti, in the ear. There are 24,000 of these.

scala media of the cochlea—we have the organ of Corti, a miniature piano having 24,000 cords of various lengths—like the varying lengths of wires in a piano. Each one of these cords has its own definite rate of vibration, or keynote, and each synchronizes with the vibrations reaching it from the exterior world

and transmits them over the auditory nerves to the brain.

Were it not for these "fibres of Corti," all sounds would be the same, and music—and also the distinguishing characteristics of the human voice, like all other sounds—would be mere noise, sometimes loud, sometimes faint.

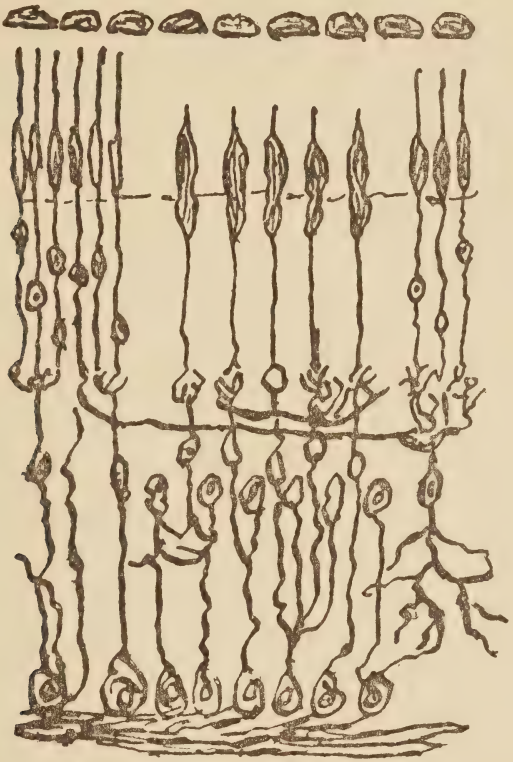


A SEPARATED SECTION OF THE RODS OF CORTI

A section of the Bacillary Membrane or Corti's membrane in the ear. (C) the cords, or rods, 24,000; (I) inner rods, 6,000; (O) outer rods, 4,500; (D) the damper, or tectorial muscle, which acts as a damper does on a piano. It is a complicated musical instrument.

The eye no less truly than the ear is a musical instrument, but it is even more delicate in its mechanism. It has a range of about one octave. The optic nerve itself does not see, the part of the retina where it enters being insensitive to light. But beneath the retina is a bacillary layer known as Jacob's membrane; this consists of eight or ten millions of rods and cones,

of varying lengths and of vibratory rates. Each rod and cone is in tune with its own particular vibration



THE RODS AND CONES IN THE BACILLARY LAYER, OR JACOB'S MEMBRANE IN THE RETINA OF THE EYE. THE CONES ARE THE SHORTER

These together constitute the ultimate organs of sight. There are eight or ten million of them. They differ in length and diameter, and in their vibratory rate. They are keyed to the pitch of the vibrations of light.

in the light waves, and with no other. Light falling upon the retina and coming into contact with the rods

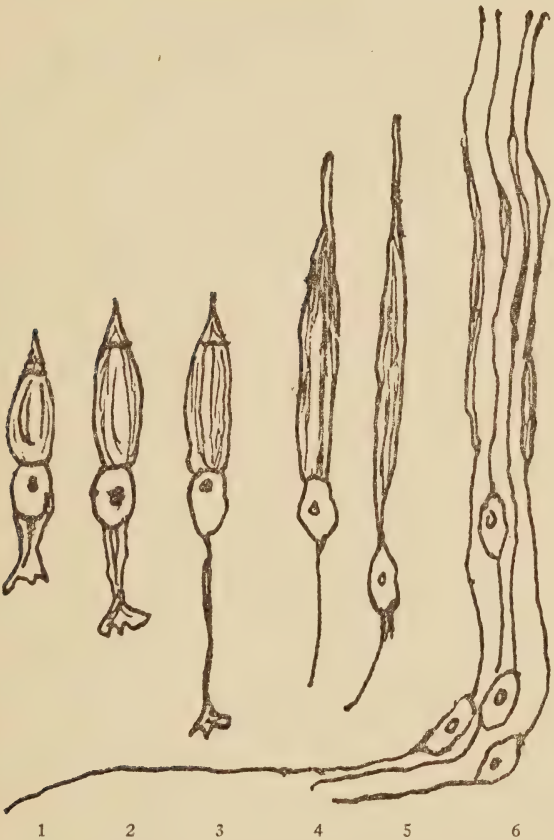
and cones finds a sympathetic response in only those rods and cones whose vibratory rate is in unison with the vibrations in the light waves; all the others remain quiescent.

Thus we notice that both the ear and the eye are marvellous mechanisms which, in conforming to the law of resonance, enables us to detect the vibrations of nature within a certain range, which are termed sound and light.

Those vibrations which are between 13 and 55,000 per second the ear detects, and we term them sound. There are about twelve octaves of these. Thirty-three octaves above the range of hearing, we come to ether vibrations, which we designate as light. There is one octave of these, or a trifle less. When 434 trillion vibrations a second fall upon the rods and cones whose vibratory rate is in unison with that number, we experience the sensation known as the colour red; 500 trillion such vibrations are known as orange; 520 trillion vibrations, yellow; 570 trillions, green; 634 trillions, blue; 690 trillions, indigo; and 740 trillions, violet.

The region between the highest sound waves and the lowest light waves—33 octaves—is occupied by the ether waves used in wireless telegraphy and the radio. The extreme range of these is from 5,000 vibrations to 300 millions a second; but those in general use have a frequency of 10,000 to 3,000,000 a second. These are limited to about fifteen octaves. Those below the colour red, from 300 millions to 400 trillions vibrations a second, are known as the "infra red" or

" below the red " rays. They are " dark light." The bolometer has detected and mapped out thirteen



THE RODS IN JACOB'S MEMBRANE OF THE EYE (1) TO (5) ARE THE CONES

Cones in different regions of the retina; (1) near the ova serrata, or the end or termination of the nerves forming the retina, near the lense; (2) at 3 millimetres from the ova serrata; (6) at the centre of forea centralis, which is the deep point of the yellow spot in the retina. The length of the external ones is about 1-5,000th inch, and the internal segments 3-5,000th of an inch, and the diameter is about 3-10,000th of an inch.

octaves of these. That delicate instrument is, so to speak, an eye which can detect light that to us is darkness.

Above the colour violet are the ultra violet rays. These cover a range of one or more octaves and are vibrations of from 750 to 1,500 trillions a second. They are detected and brought down an octave or so, into the range of vision, by the response made by such substances as calcium sulphide, whose atomic rate of vibration is in the same key, yet an octave or two lower.

The X-ray vibrations, several octaves higher still, range from twenty-one quadrillions to 400 quadrillions of vibrations a second. Some scientists have calculated their extreme limit as much higher; that is, 5,360 times that of sodium light, or two quintillion, 700 quadrillion vibrations a second.

For the human mind to comprehend any such a number is utterly impossible. If one million persons had begun counting those vibrations 6,000 years ago, say when Adam lived, and had counted day and night without intermission at the rate of one a second, they would have to count on yet 2,800 years to reach the number made by the extreme X-rays in a single second. In other words, it would take our million people 8,838 years to count them.

No eye can see them, for they are several octaves above its range, but through the sympathetic response made by the atoms of platinocyanide of barium they are brought down into view.

All these vibrations, from the lowest in sound to the

highest in the X-rays, comprise fifty-seven octaves. We are so constituted that, through our nervous organism, we can detect thirteen octaves or less. It is estimated that the gamma rays from radium vibrate 150 quintillion times a second, sixty-three octaves above the first A of sound waves.

Were we possessed of a continuous series of delicate nervous fibres, from the longest one in the ear to the shortest and most sensitive one in the eye, we should be able to see and hear all the tones, from the thirteen a second in sound to the 740 trillions in the colour violet. Even then, however, we should be able to recognize only a small fraction of the vibrations with which we are surrounded in the world. It has been estimated that the sum total of vibrations in the natural world comprise 300 billion octaves. To represent them in an adequate scale we should have to extend the scale from the earth to the sun; and in that scale the light band which we see would comprise only eight ten-thousandths of one inch. A vast ocean of such waves of energy lies outside and beyond us, to which we are utterly oblivious in our present contracted existence. Doubtless sometime we shall be able to compass and comprehend them all.

A thin parchment is stretched from the four corners, and upon this is placed a soft, yielding liquid paste. A musical instrument is played over it, or some popular air is sung over it. Now, under the touch of the waves of music, the soft paste arranges itself into all kinds of beautiful forms, never in an indifferent irregular mass. Beautiful vegetable forms, ferns, flowers, stars

of all shapes and even miniature landscapes arrange themselves under the spell of different strains of music. Here we see music turned into visible forms.

The Creator spake, and the rhythmic tones of His voice took visible shape in the flowers, and in the myriads of beautiful forms seen in the world. They are the music of His voice become visible. We have but to reverse the order to have the vegetable and other beautiful forms turned into music. And that is exactly what is occurring in nature.

Frances S. Osgood has expressed it thus:

> The Father spake! In grand reverberations
> Through space rolled on the mighty music tide,
> While to its low, majestic modulations
> The clouds of chaos slowly swept aside.
>
> And whersoever in His rich creation
> Sweet music breathes—in wave, or bird or soul—
> 'Tis but the faint and far reverberation
> Of that great tune to which the planets roll!

The atoms of all bodies are in motion; when they are unrestrained they arrange themselves into harmonious and beautiful shapes. This tendency is seen in the numerous star-structures of snowflakes; in the beautiful fern-like and feathered figures of frost as it forms on the window-pane; in the numerous varieties of crystallization of minerals; in the leaves and flowers and multitudinous other beautiful forms of animate and inanimate nature. All these are simply visible music.

When sweet tones take the shape of lilies and stars and ferns, has the music ceased simply because our

ears are so dull that they can no longer respond to the rhythmic vibrations? If our eyes and ears were greatly enlarged in their range, and quickened in their delicacy of response to vibrations, what wonders we should behold, and what sounds we should hear! Every piece of music, like Haydn's "Creation," would be seen to be composed of the most beautiful colours, blended in exquisite harmony. We would go out and look upon nature, and the hills would break forth before us into singing. Delicate and soul-stirring harmonies would be heard on every hand.

The autumn forests, painted in countless brilliant hues, would be continuous strains of music of the most delicate and perfect cadence. All the plants and every flower, the gorgeous sunsets, and rainbows, the fleecy clouds and every ray of light streaming with various colours, from the myriads of sun-stars, would be heard pouring forth their notes of exquisite sweetness.

All nature is musical, singing her notes of sweetest praise, and the sun, moon, and stars join in the chorus. The "music of the spheres" is more than a poetic fancy. It is a scientific fact. *συμφωνία*, sumphonia—music—is the plural of *σύμφωνος*, sumphonos; "symphony" is the word employed by Aristotle to describe the music of the spheres.

"The outgoings of the morning and evening rejoice," or sing (Ps. 65:8). The rising and setting of the sun cause varying degrees of heat to fall upon the air from the sun, creating delicate shades of sound vibrations, with the result that the sunrise and sunset are attended with music.

The Hebrew word translated "sing" or "rejoice" in the passages quoted above could not be a more perfect picture of the wave vibrations of sound and colour. It is the same word in each case, רָנַן, rahnan, and signifies "to give forth a tremulous and stridulous sound, as of the creaking, whining sound made by a mast, or tall pole, by a bow string, by locusts, grasshoppers and other insects; and finally comes to mean, to sing or to shout" (Gesenius' *Hebrew Dictionary*).

Who has not watched the gorgeous tints of the clouds toward sunset, and noticed how the colours pass from the delicate streaks of violet to golden yellow, and then become tinged with purple, and change once more into green, yellow, red? The whole musical scale, from the lowest bass in the red, to the highest soprano in the violet, is being run back and forth in all such displays of colours at sunrise and sunset.

All the various shades of colour seen in autumnal forests and flower gardens, in the rainbow and in the clouds, are ever changing from one hue to another; a fact which means that the notes of nature are being successively touched, awakening sweet and perfect harmonies. Would that our ears were able to hear what our eyes can see!

Fourth. Numerous phenomena of nature illustrate the naturalness and reasonableness of the vicarious atonement of Christ as presented in the Bible.

Many of the most important processes of nature are vicarious. Indeed, this statement is so true that it would seem as if our very existence and the existence

of every living thing and of the universe itself were bound up with and dependent upon a law of vicarious service.

It would be almost impossible to recount all the benefits which man, all other living things and the earth itself receive from the sun. It always has been known that sunlight has a salutary effect upon nearly all diseases. It has been used in all ages, all the world over, by both scientific men and savages. The utilizing of solar energy as a curative agent is as old as the race. But it is only since the work of Finsen of Copenhagen, in the last decade of the nineteenth century, that phototherapy, or heliotherapy, has been established upon a sound scientific basis. He succeeded in demonstrating that it is the light at the short-wave end of the spectrum which contains the therapeutic rays.

Nevertheless, in the earlier and cruder methods of using the sunlight, most beneficial results were experienced, especially in cases of tuberculosis. Nowadays, patients with pulmonary and bone tuberculosis are urged to expose themselves to the sunlight for long periods of time; and those persons show the most improvement who lie naked, or nearly so, in outdoor sunlight. The results are better in direct sunlight than in solaria, under a glass roof, for the glass does not transmit the ultra-violet rays.

The sun rises upon us with healing in his rays. But it does more. It feeds us, slakes our thirst, warms us, clothes us, houses us, lights us, runs all our machinery, gives us all our beauty, enables us to live and breathe

and perform our every physical exertion and to use our brain as a thinking instrument. Without the sunlight we could not hear, see, smell or taste. About the only thing possible to us would be to feel, and that for only a brief time—to feel pain and suffering which would speedily terminate in death.

Our food and clothing are transformed sunlight, stored up in vegetable and animal life. Our fuel, lights and buildings are sunlight stored up in coal, wood, oil and electricity. The sun raises all the vapours and gives us rains and fruitful seasons, our water power, our rivers and springs, our grains, flowers and fruits.

The sun severs the carbon from the oxygen in the carbonic acid gas in the air, and builds the carbon into vegetable forms. This process is carried on in the leaves, through their stomata—mouths or pores. The work is possible only during hours of sunlight, when the stomata are open; they close in darkness. The luminous energy stored up by the chlorophyll enables the protoplasm of the leaf to transform the mineral substances of earth and air into those organic products, complicated and charged with energy, without which the life of animals would be impossible.

During the hours of darkness plants absorb oxygen and exhale carbonic acid, as do animals. This is a respiratory function, or oxidation; it is a burning up, or death. In sunlight the chlorophyllian function, the converse of the above, occurs; in this process the plant decomposes carbonic acid and fixes the carbon in its tissues. This is a winding up of energy; the other, a running down.

All this beneficent work for plants and animals, with an incomprehensible amount more in every conceivable way, is due to the vicarious action of the sun. To sustain and bless us thus, the sun is giving up its very life. It dies that we may live. It gives without stint, but its giving means its death. Like a generous parent, the time will come when it can give no longer; it will expire. All because it has constantly given out. The marvel is that it can give so much. "The whole heat emitted by the sun in one minute would be competent to boil 12,000 millions of cubic miles of ice-cold water."

Large regions of the earth's surface were made and were made habitable because of the fact that myriads of creatures yielded up their lives in order that a foundation might be laid for man. "Minute limestone-encased creatures float on the water while they live, and at their death give their skeletons to the sediments of the sea floor; in which way massive limestones, such as the chalk deposits of England, have been produced."

Of the same origin are the shell or chalk formations which range across the north of France, Belgium, Sweden, Denmark, Russia, and the northern part of Germany, through Greece, Sicily, the north of Africa, along the Nile and in Arabia and across Syria.

During the time when the Atlantic sent its waters across Europe and Asia there gathered at the bottom vast masses of calcareous deposits, composed in great part of the corpses of microscopic foraminifera, nummulites, mollusks, corals and echinoderms, and numerous others, imbedded in the deposits of Globi-

gerinæ, which formed the chalk of the cretaceous epoch.

The countries mentioned above, and in fact all others on earth, have as their foundation an immense cemetery of former generations of living creatures. The Pyramids and the Sphinx in Egypt are composed solely of the remains of the nummulites.

In the ancient seas of the Paris basin the miliolitic foraminifers were so numerous that, upon dying and settling down, they formed mountains which are now quarried and built into towns; most of the stone houses of Paris are composed simply of the carapaces of these mollusks, compressed and agglomerated into solid rock.

So extensive have been similar fossiliferous deposits that writers on paleontology have said that the earth's surface is only an immense graveyard, in which various generations of animals have left their skeletons to form a deposit for the beings which should succeed them.

The city of Berlin is built upon one of the cemeteries of such animalcules, and Richmond, Virginia, is the centre of such a district; there, as Shelley expressed it poetically, "every grain of dust was once endued with life."

The very lime rocks round about Jerusalem are composed of the remains of myriads of creatures that gave up their lives in order that a foundation might be laid for man—and an altar erected on which the great sacrifice for his sins might be offered. "And this fact is significant of the higher fact that the atonement of Christ is the grand continuation, or rather the

Divine climax, of that system of intervention and vicarious suffering which pervades the natural world, alleviates so much of its misery, and adds so much to its beauty and order. We see the law of vicarious action at work in the plant yielding up its life in order that the animal may be nourished, and in the sacrifice of the animal in order that the nobler life of man may be sustained." [1]

The energy released in radioactivity is due to a process of degeneration, a death of the atom. Nature is running down, and we reap the benefits of the energy thus passed on to us.

The action of an electric current, also, is vicarious. According to a well known rule, " whatever action an electric current may exert, that action acts contrary to the current." To put it briefly, all acts of an electric current are suicidal.[2]

Again, in the vegetable world the law of vicarious sacrifice is everywhere at work. The seed is placed in the ground; the first process which takes place within it is one of decomposition. The seed dies, to release its life to other and succeeding generations. Hugh Macmillan puts it in this way: " All nature is deciduous. The branch is sacrificed that the blossom may be produced; the blossom falls that the fruit may be formed; the fruit drops that the seed may grow." Jesus said that except a grain of wheat fall into the ground and die, it abides alone, but if it die, it brings forth much fruit (John 12:24). And, " Whosoever

[1] Hugh Macmillan, *Two Worlds Are Ours,* p. 21.
[2] *The Electron Theory,* Fournier D'Albe, p. 132.

will save his life shall lose it; and whosoever will lose his life for my sake shall find it" (Matt. 16:25).

That is the law of nature. Life is maintained only by an incessant using up of the materials transmitted to it. Instability is the law of life. The cell dies without ceasing. As soon as stability is reached, then comes death. "Life is an action produced by its opposite. It has its root in death and is nourished by decay."

In all life two processes are at work. First there is organization, but there is also of necessity a simultaneous disorganization, or decay. Death is essentially a part of life.

This principle is as true in animal life as in vegetable life. Decomposition of organized materials within the body produces an increased nutrition. So we have in digestion a process precisely similar to that in the germination of the seed. There must first be death.

No one can even think without dying. Brain cells must first perish, if thought is to exist. Again, no one can act until there has been death; the cells must perish that the energy, in muscular activity, may be released. The sensation of warmth, resulting from muscular exercise, is due to the more rapid oxidization, or burning up, of the tissues.

Through the whole animal creation this law of vicarious sacrifice is seen at work. In the lowest forms of life the offspring are formed by the literal breaking up of the parent. But as we ascend the scale of life we behold just the same process; the life of the young

is sustained at the sacrifice of the mother, and at birth her young are torn from her—often at the sacrifice of her life.

The honey moths, which do so much damage among bees, sometimes get into the hive, notwithstanding the vigilance of the guards; there, in the combs, they deposit their eggs. They are able to enter because they run very rapidly and are able to fold their wings into a small space over their bodies, so as to offer no impediment to their feet. "When one of them," says J. G. Wood, "has succeeded in slipping past the sentinels, there is a grand commotion in the hive, each bee chasing the galleria moth and endeavouring to secure it with its teeth, when its fate would be instant death at the jaws of the infuriated multitude. But generally the active little creature, having once obtained an entrance, fulfils the object for which it came there; for after running and doubling and twisting about among the combs, it evades its enemies and secretes itself in some crevice, where it deposits its eggs in safety. The object of its life is now accomplished, and it cares little what becomes of itself afterwards."

Dr. Hugh Macmillan adds this contribution to the subject:

"It would be impossible to enumerate all the striking examples of vicarious or substitutionary action to be seen in the natural world. The very commonest processes of nature are mediatorial. And the same principle follows into the higher sphere of human life. The whole fabric of the moral world is held together by this principle. From the moment that the mother gives birth to

her child—alas! too often at the sacrifice of her own life—to the hour when loving hands wipe the death dews from her brow and loving hearts are wrung with the agony of bereavement, there is hardly a joy that we feel, or a trouble from which we escape, which we cannot trace to the mediation of another, often effected through pain or loss or sorrow to the mediator."

We see the same law written in our bodies. A paralysed or dead portion of the body has no power to suffer. Pain is experienced only by the living and healthy portions of the body. If cells are pierced, through the wounding of the body, they are in fact killed. If inflammation occurs, the suffering must be borne by the healthy cells. But the necessary tasks which one organ fails to perform are done by others. They shoulder the burden, as far as possible. If the skin fails, the kidneys do more work, and vice versa. If the stomach is weak and is unable properly to digest the food, the bowels do more work. The use of the mustard plaster depends upon this law. It is designed to produce phagocytosis, or the destruction and absorption of bacteria or microbes by the phagocytes or white blood corpuscles. These corpuscles rush to the place in the body which has been irritated by the mustard, ready to do battle with the enemies which have caused the trouble. The skin is stimulated in order that it may do the work of the kidneys, liver or lungs until they are able to go on with their tasks in a normal manner.

We cannot fail to see the resemblance of these processes to the sacrifice of Christ. He is represented

as the head of the body, and He is the healthy part. The members of His body are represented by men who have received the wound of sin, and who are not feeling the keen pangs of suffering, but are rather content in their state of death. The pain is felt in the well part of the body—the Perfect One—and He bears all the burden that comes as a result of the failure of the other parts of the body. He becomes the sufferer, and burden-bearer, for the whole body.

But in nothing else is this principle better illustrated than in the battles, even unto death, which are fought by those white blood corpuscle phagocytes for the protection of the body. A theory of immunity from disease was presented by the famous Russian bacteriologist, Elie Metchnikoff, in an article on the "Relation of Phagocytes to the Bacillus Anthracis." According to this scientist, "the leucocytes, or white blood corpuscles, appear to have the power of destroying bacteria in some cases. If the bacilli of the anthrax are inoculated in the frog, the white blood cells are seen to incorporate and destroy them, until they entirely disappear, and the animal is not affected. If, however, the animal is kept at a high temperature after inoculation, the bacilli increase so rapidly that they gain the upper hand over the leucocytes, and the animal sickens and succumbs.

"The leucocytes, then, may be regarded as a soldier-like community, one of whose special offices is to fight to the death the invading hordes of pathogenic microbes. Hence Metchnikoff's expressive term, 'the battle of the devouring cells against the cause of dis-

ease.' These fighting leucocytes have been called phagocytes; from φάγειν, I devour, and κῦτος, a hollow, hence a cell. Devouring cells. They are endowed with powers of movement and, amœba-like, are capable of pushing out and withdrawing portions of their bodies. Into the retracted portion of one of these phagocytes a microbe is received. It is finally enveloped, becomes cloudy and disappears by absorption or digestion."

Dr. James Ewing, in an article in *The New York Medical Journal,* states that after a series of careful experiments he discovered that when bacteria and their products were injected into rabbits the blood in that part of the body receiving the injected microbes soon contained vastly increased numbers of phagocytes. They gathered like a mighty army, as if to do battle with the new enemy. For when the blood in other portions of the body was examined it was found to contain the phagocytes in greatly diminished numbers.

"Some time after intravenous injection of certain bacteria and their products, the majority of the leucocytes, especially the multinuclear forms, disappeared uniformly from all parts of the arterial and venous circulation." These, having attacked the bacteria, had carried them as prisoners of war to the sewers of the system, to have them cast out. "The leucocytes that disappear after the bacterial injections are to be found, more or less stationary, in the capillary vessels, especially in the lungs and liver." These corpuscles take upon themselves the burden of ridding the body

of its bacterial enemies and, if need be, of suffering death to accomplish this purpose; it has been proven that the injection of bacterial products into the circulation may destroy the phagocytes.

The process of repair of the body in wounds is not done by its own exertions, but is carried on by these white corpuscles. "The process of repair is identical in all tissues. The reparative process in bone or muscle, integument or tendon, is the same. If we closely examine the surface of a wound thus exposed, we shall see that it becomes, within a few hours of its exposure, covered with a film of peculiar gelatinous, grayish-white appearance, which will be seen, with the aid of the microscope, to be composed of granulation cells or white blood cells."

A large accumulation of these cells occurs at the wound, and these carry on the work of repair and are given off as healthy pus, if the processes of construction and regeneration are being successful, but as unhealthy, or dead pus, if there is disease in these granulations. Here, as in the other cases presented, we have the vicarious sacrifice of Christ typified. He fought the battle for humanity.

"It is most significant," suggests Hugh Macmillan, "that it says that the Lamb was slain before the foundation of the world; and this Divine statement was meant to refer not only to the purposes of God and the arrangements of human history, but also to the constitution of the earth itself. Redemption was no accident, no afterthought, no desperate remedy suggested by the necessity. The Lamb was verily fore-

ordained before the foundation of the world, and redemption was the keynote of creation, to which all its parts and purposes were set in tune."

Let it be remembered, also, that the vicarious sacrifice of Christ was not felt to be a painful thing which must be shunned; it was not a thing from which He would shrink.

When He announced that, moved by the compulsion of His love for humanity, He must go to Jerusalem and suffer many things and be killed, Peter took Him in hand and began to rebuke Him for making such a rash and unreasonable announcement of the end of His earthly career: "Pity yourself, Lord; this shall not be unto thee. You can easily avoid all that." But He rebuked Peter as an instrument of Satan in seeking to tempt Him from His chosen course. "Your outlook is not God's, but man's."

Man's "outlook" is that sacrifice should be avoided, and that, when it comes, it is felt to be painful. But that is only because man's love is so feeble. In vicarious sacrifice love is a spiritual anæsthetic; all sense of pain is obliterated where it reigns.

Pain is the sign of weakness and disease. The weak and sickly body finds it painful to lift a small load or to make any physical exertion which is a pleasure to the athlete. What is a torture to the rheumatic is a joy to the strong man.

Christ is the Man of perfect health in our humanity; so it was a joy to Him to endure the cross for our sakes. We are the sickly, the rheumatic, part of humanity; it is we who find vicarious sacrifice pain-

ful. If our love were perfect, like that of Christ, our substitution, expiation, propitiation, the strong bearing the infirmities of the weak, the just suffering for the unjust, the sinless for the sinful—none of these would be painful to us.

In proportion as love controls us, like any other powerful emotion it can banish all pain in our vicarious service for others. The miser finds it painful to part with his money, but when the life of his only son whom he loves is at stake, he gives his money gladly. The mother, because of her love for her children, finds it not painful to deny herself of sleep or rest or to toil in their behalf.

God, being love, could not be content unless He gave us the best thing He had to give—and that was to join us with Himself in giving. There are the best of reasons for believing that when Christ prayed, "Let this cup pass from me," He was asking not to be delivered from the cross, but rather to be delivered from death then and there in the garden, death which was imminent at that very hour because of the excess of His agony. It is known that in cases where hematidrosis, or sweating of blood, occurs death speedily ensues.

Had Christ died in the garden, His would have been to the world a death similar to that of all other human beings; not at all would it have been evident that it was of a sacrificial nature. He chose rather the death on the cross, a death which He had foretold to His disciples and to which He had given Himself before the world was.

Now, Christ being Himself the Creator of all things, eternally had in mind His redemptive sacrifice. We might therefore expect to find, and we do find, nature everywhere manifesting substitutionary and redemptive processes—the strong bearing the infirmities of the weak and dying that they may live. This principle runs like a scarlet thread through the whole warp and woof of the universe. That thread is dyed its deepest red in the blood of Christ on the cross, on which He becomes the Sacrifice that takes away the sin of the world.

As we have proceeded we have seen that nature influences man in body, mind and spirit; and that this influence is not fortuitous—it proceeds from benevolent design and is for our nourishment, body, mind and spirit, for our highest good.

Furthermore, nature was intended to be our schoolmaster to bring us to God. She speaks in symbols, and is able to confirm in a marvelous manner the Divine revelations in the Bible and in Christ and to teach the deep things of God, to those who approach her with an earnest purpose and devout spirit. Those and only those experience the truth of Goethe's words:

> Wouldst thou with thy bounded sight
> Make survey of the Infinite?
> Look right and left and everywhere
> Into the finite; you'll find it there.

Looking thus, we gaze up through nature to nature's God, and we behold Him imminent in all things, our

Father, Redeemer and Friend. We look within, and find Him there, also. He is at home in nature. There, too, we dwell; there we may touch His hand, see His face and enjoy companionship with Him.

Nature is our other half—to which God has joined us in the bonds of holy wedlock—and death is the only lawful divorcement. Let us live in harmony with her, and join with her in her myriad-voiced cadence, in the sublime and universal magnificat heard and vocalized by the beloved apostle on Patmos' lonely peak: "And every created thing which is in heaven and on the earth and under the earth and in the sea, and all things that are in them, heard I saying: Unto him that sitteth on the throne, and unto the Lamb, be the blessing and the honour and the glory and the dominion, for ever and ever." For "His glory is the fulness of the whole earth."

VII

THE CIRCULAR AND ONWARD MOVEMENTS

THE generations come and go, but where the earth is, there it shall remain. The rising sun goes down, it hurries round only to rise again. From south to north the wind blows round, the wind turns as it blows, turning and then returning on its track. The streams all flow into the sea, but the sea they never fill; and unto the place where the streams go, there they go again. That which has been is that which shall be, and that which has been done is that which shall be done, and there is nothing new under the sun. Whatsoever is, it has already been; and God is ever bringing back what disappears."—Ecclesiastes 1: 4-7, 9, 10; 3:15.

Here is stated a circular and onward movement in nature and among men; and God is represented as bringing back what has disappeared.

Discriminating observers of nature in general have recognized the circle as the archetype or pattern of all forms, physical as well as mathematical. Nature does not attain her ends in the most direct way, by moving across the shortest distance between two points—in straight lines—but in a roundabout way.

All objects, organic and inorganic, have a tendency to assume the circular form. It is thus that they attain their perfection. All worlds, plants, animals and trees; all cells, molecules and atoms; all living, magnetic and

electric forces move onward, finding their consummation in conical and rotund forms.

One can hardly fail to observe the circular and onward movements in nature. We see the wind blowing strongly, then suddenly beginning to whirl, carrying leaves, dust, small sticks and twigs with it; if the whirlwind be very powerful, it carries into its vortex parts of persons' clothing, hats and even large bodies, wrenches buildings from their foundations, twists off large trees with apparent ease and produces fearful devastation.

Not every one, however, is familiar with the fact that there are recognized laws of the winds. The baric law of the wind is the law of relation to pressure, according to which winds blow spirally from right to left; and the law of storms states that " the wind has two directions—rotary and progressive; the rotary counter-clockwise—that is, from west to east—in the northern hemisphere, and clockwise in the southern hemisphere.

There are numerous influences, atmospheric, electrical, astronomical—such as sun spots and tides, the ocean currents, the contour of continents and of mountain ranges—any and all of which tend to modify and change the air currents, which we term winds, caused by the revolution of the earth and by the variation of temperature at the earth's equator and poles. But it has been observed that in general the winds obey the baric law and the law of storms.

What interests us principally in this connection, however, is the fact that the winds tend to move in

circular forms, as stated in the Scripture quoted above. " From south to north the wind blows round; the wind turns as it blows, turning and then returning on its track." It is remarkable that the writer of the book of Ecclesiastes 2,500 or so years ago correctly states what scientists of these days have discovered. It is but recently that men have known that the earth is a sphere; that there are tropics and polar regions, that the heated air from the equatorial regions, rising, travels northward, and that the arctic currents flow southward; so the " wind turns as it blows, turning and then returning on its track."

Water, also, passes through circular and onward movements, and in numerous interesting ways. Immense volumes of vapor rise from the seas and fall as rains. The amount of water so lifted into the air is indicated by the rainfall. In the tropics this is enormous. Dr. Guyot says that twenty-three feet has marked the annual rainfall in Brazil and twenty-one inches that of a single day in Cayenne, in French Guiana. As a consequence, floods of forty feet or more occur in the great rivers of South America.

Water falls as rain, percolates through the soil, collects in reservoirs lying between the layers of rock, and from these reservoirs flows through the underground veins and out as springs, forming the creeks and rivers, and wends it course back to the ocean. Much of it is absorbed by, and circulates in, vegetation, whence it enters into animal bodies and courses in their tissues and in their blood, and at last it completes its round in being given off as watery vapor, to form rain once more.

Every drop of water wanders through devious series of circuits from sea to air, to soil, to vegetable life, to animal life, and through myriads of other channels, but it never ceases its journey. Thus it has continued from the dawn of creation, and thus it will go on as long as the world endures.

Nature in general manifests the same laws of circular and onward movements. Light passes through such a cycle, even more tortuous and involved than that manifested by water. The sunlight falls upon the earth and becomes stored up in vegetable structures. A portion of it forms fuel in wood and coal, then by chemical processes is liberated as heat, to turn the wheels of commerce, and becomes manifested as electric energy and lights our homes; it completes the cycle in its return as ether waves to the sun. Or its course may be more intricate; it may be transformed from vegetable to animal existences and then into human beings, warming them, healing them, energizing them, burning up the waste products of the body; it is transformed into physical and mental energy and performs numerous other beneficent operations on its journey back to the ether and finally to the source of its origin.

According to the popular Einstein theory of relativity and gravitation, light waves follow a curved path, returning ultimately to their starting point; and space itself is curved. In other words, if light and space be sufficiently continued, they form great circles and return back upon themselves to their starting point.

Electricity traverses its circuits, extending from the generator back to it again. Unless the circuit be com-

plete, the current will not flow. We speak of a regularly recurring series of values of an electromotive force—from any point in the series to the corresponding point in the next series—as a cycle. Also, the lines of force in an electric current are circular, moving around the wire over which the current passes. The pull of a permanent or of an electro magnet is due to lines of force about the magnet which are circular in form. So all forces seem to reach perfection, or their ultimate objectives, by moving not in straight lines but in circles.

The earth and all other heavenly bodies exhibit circular and onward movements. While the earth and all the other planets are traversing their orbits about the sun, they and the sun, together with all the other suns in our universe, form an immense spiral; they travel onward through space, following a course somewhat like the cylindrical thread of a great screw.

The movement of the earth in its orbit gives us the cycle of the seasons, spring, summer, fall and winter; and each spring we have apparently returned to the place which we left a few months before. But actually we are 365 days, and many millions of miles, further on in our spiral journey through the heavens. And while we are travelling thus we see that the sun has its cycle of sunspots, exhibiting to the universe its seasons of relative heat and cold, calm and storms, and that the greater and more distant suns, known as variable stars, pass through similar cycles, their light waxing and waning as they move onward in their spiral courses.

All animal life reveals this law. The migrating birds fall into line with the circuit of the seasons, build their nests, rear their young, forsake their summer haunts and hasten to the reeds and brakes and palms of the south, only to repeat their experiences with the flight of time. The hibernating animals awake from their sleep to complete their cycle of life. The peepers cry from their home in the bogs to tell us that they, too, have started on another circuit.

In the smaller and more minute details, also, all living things obey this law. The egg is deposited, and in due season the larva appears, passes through its chrysalis, and becomes the winged creature—which deposits its egg; and the egg will continue the process. Caterpillars and moths, locusts, grasshoppers and dragonflies are only a few of the multitudinous forms which make this ceaseless round along with other beings in nature.

A single case is illustrative of them all. The galls on the leaves of the oak, from which inks and medicines are made, are the home of an egg deposited by a wingless creature known as Biorhizas. This creature was born from an egg on the roots of the tree; it climbed the tree in a slow and deliberate fashion, and deposited its egg on the leaf, which formed the gall; out of this gall was hatched a winged creature called Teras—"monster"—which in turn descended to the root of the tree, there to leave its own eggs, which will be born as Biorhizas—"life and root."

Human life passes through similar cycles: "The generations come and go." We, also, pass from child-

hood, through the experiences of life, and arrive again at the childhood period of old age.

The blood completes its cycle in the human body in about thirty seconds, to leave the heart again in its round of life. The circulation of matter in the body, and the circulation of impressions in the nerves and of impulses in the muscles, are helps and means in physical growth. The matter indwelt by our life has been used and reused millions of times, from star dust to spiral nebula, up and down the processes, through vegetables, animals and even other human beings.

The elements which constitute the human body are no sooner comfortably fitted into place in the tissues, muscles, skin, hair, and so on, than they begin forthwith to be dissolved out again—to be decomposed and removed from the bodily structure. So rapid is this circular and onward movement of the materials composing the body that physiologists have inferred that the entire body is changed and renewed in a period of less than thirty days. All its parts are in constant flux; the materials of which it is composed are in perpetual circulation and perpetual change. Nothing belonging to it is permanent, nothing is fixed or abiding. It is not the same on any two successive days nor even during any two successive hours.

Action and reaction is the law of man's life. The temperature of the body has its cycles, the maxima and minima corresponding to the revolutions of the earth; so the fire of life follows the sun. The temperature rises to its highest point in the afternoon and

falls to its lowest in the hours after midnight, at which time death claims most of its victims.

The human mind, also, seems to have its cycles; we are told that "history repeats itself": "That which has been is that which shall be, and there is nothing new under the sun."

"Phases of human error and folly are found occurring again and again, after long intervals. Delusions and deceptions, religious and social, are seen manifesting themselves in the world long after it had been fondly hoped that they were dead and buried. The persistency with which forms of faith and aspects of society appear age after age is truly marvellous. Fashions of dress return, schools of art and philosophy, theories of science and theology have the same kind of periodicity which marks the phenomena of nature."

At present the old one-fluid atomic theory of electricity, formulated by Franklin in 1750 in his letters to Collinson but long discarded, has been so far revived by the intellectuals, that if the present electron theory were put into Franklin's language, it would almost seem as if we were listening to the statements of a Kelvin or a Rutherford regarding the real nature of light and electricity.

Like the theory of descent in biology, originated by Empedocles in 450 B. C. and adopted a hundred years later by Aristotle, reopened by Leibnitz in the seventeenth century, discovered anew and espoused by Lamarck about a century later and deduced and formulated anew by Darwin and his confrères, so the

ancient corpuscular electric theory under a new name is again enthroned and is destined to rule, we know not how long.

Goethe, in his Eins und Alles, says:

> To recreate the old creation,
> All things work on in fast rotation,
> Lest aught grow fixed and change resist;
> God's universe can know no rest.
> It must go on creating, changing,
> Through endless shapes forever ranging,
> And rest we only seem to see.
> The Eternal lives through all revolving;
> For all must ever keep dissolving
> Would it continue still to be.

But in all this there is not absolutely a return to the same place whence we started; progress has been made. We are travelling in the form of a spiral. At ninety years of age we may have arrived at our second childhood, nevertheless we are a long way from where we began. Our life is a coiled spring, ever returning back upon itself but stretching forward into eternity. This is precisely the aspect which nature assumes in its onward march.

Such a principle is beautifully exemplified in the arrangement of the leaves around the stem of a plant. They are never haphazard, but take the spiral form. "Let a line be drawn around a twig of any of our fruit or forest trees, from the base of one leaf to the base of another, and so on to the base of each succeeding leaf, and it will be found that a beautiful spiral line has been described, the cycle ending with the leaf directly above the one from which we set out."

The pine cone is modelled after the pattern of the whole tree, its scales running in spiral form, as do the branches of the tree; and this is not surprising, for both are formed by the same laws. These are the laws forming and controlling our own bodies, and also all things both visible and beyond the ultramicroscopic; so that the smallest detail of nature represents in itself, and is a miniature of, the magnificent totality of creation.

It is worthy of note that trees from base to tip are, by the yearly layers of growth, really formed of hollow cones, each one of which, from the first year's, is formed over the one of the preceding year. Were it possible to separate them from a tree, say, seventy-five years old, we should have seventy-five cones, the largest of which would be perhaps two feet in diameter at the bottom and sixty feet long. These cones would fit into one another. The one formed by the first year's layer would fit into the second year's, and so on, like nests among cooking utensils. But they would all possess a twist or a spiral running from right to left, from bottom to top. The cone possesses in itself all circular forms; for it has long been known that the circle, the ellipse, the parabola and the hyperbola, all can be formed by different sections of the same cone.

From the circular and onward movements such as are mentioned in the Scripture texts we derive our stability of life and nature. If it were not for these movements, everything would disintegrate. The motion of the gyroscope reveals to us this fact. And in the spinning of a top its motion in any plane imparts

to it a rigidity which is surprising. Could we spin it fast enough, its rigidity would be sufficient to overcome the law of gravitation, and it would remain suspended in the air—on the same principle as now keeps the planets and sun suspended in space while they continue their revolutions and persist in their spiral paths. Every rider of a bicycle, pitcher of a baseball or conjurer who throws his knives in order to catch them takes advantage of this law. The stability of a body in motion, such as a top or bicycle, as we know, ceases to be possible when the velocity of rotation descends below a certain limit.

The gravitative force of the sun on the earth, which curves it into its orbit about the sun, is equivalent to four quintillion tons; this is equal to the breaking strength of the best steel cable eleven inches in diameter on each square foot of a cross section of our globe; consequently, were it not for the sun's pull, the whole world would have to be virtually covered with solid steel cables to keep it in its orbit.

The earth is so stable in its orbit that if Archimedes, weighing 150 pounds, with his lever weighing nothing, succeeded in moving the earth from its path one inch, with his lever one mile from the earth, this lever would have to be 88,000,000,000,000,000,000,000 miles long; when he applied his weight he would have to travel with the speed of light—186,000 miles a second—1,300,000,000,000,000,000 miles; it would require 230,000 years to complete his task—and he would need to continue dropping through space for 227,850 years longer.

THE GREAT NEBULA IN ANDROMEDA

It was the photograph of this nebula taken by Dr. Hubble at Mount Wilson observatory which finally solved the riddle of the nebulae. (*See page 111.*)

As we have previously stated, our speck of dust called the earth, with all the other seven planets in our solar system, and our own sun, which is a million times larger than the earth—all combined being only a grain of sand compared with the trillions of suns in the heavens together with the other stars visible to us and the Milky Way—constitute what we term the universe. It contains from several billion to one trillion stars. At a great distance it would be seen to be shaped in the form of a flat watch-case, its largest diameter being several hundred light years, and its thickness in the centre from five to ten thousand light years across. This universe sweeps on through space in the form of a mighty spiral. The stars in the galaxy are so far distant that their light blends together and appears as a faint haze over the arch of the sky. All these we term the universe, but it would be more in accordance with the facts as now known if we called it our universe; for there are numerous others.

More than 100,000 of these spiral nebulæ are known to astronomers. Until very recently there was marked diversity of opinion, and no little controversy, as to their nature. They are so far away that the only spiral nebula visible to the unaided eye is the great nebula in the constellation Andromeda.

Using the largest telescope in the world, the 100-inch reflector at Carnegie Institution's Mount Wilson Observatory, at Pasadena, California, and aided by photographic processes, Dr. Edwin Hubble solved the mystery. That great nebula, and many other heavenly objects which look like pinwheels in the sky, the

spiral nebulæ, consist of countless myriads of stars. These nebulæ are termed island universes. The one in Andromeda is so far distant that it requires the light about one million years to reach us. That is, the light which was reflected into Dr. Hubble's eye and which impressed his photograph plates was the light of those suns as they shone a million years ago. There is no possible way by which we can see that island universe as it is today. It is by far the brightest object that has ever been seen by man on this earth. Our sun, if placed at that distance, would have to be a thousand times brighter than it is in order to have any chance of being seen by a telescope or found on photographs. It contains three or four billion stars, and its total light is a billion times that of our sun.

The beautiful nebula in Triangulum, a constellation near the feet of Andromeda with third and fourth magnitude stars in the corners of the triangle, is another island universe; it is believed to be more than a million light years distant.

When we add to these spiral nebulæ or island universes the 100,000 others, we are prone to exclaim: "What is man, that thou art mindful of him?" We realize in a measure the truth in Pascal's paradox: "We are little, almost the least and weakest of things; but we know that we are little, and therein we are great."

We are able to recognize God's power and wisdom in the circular and onward movements in creation, and to realize that except for this law enunciated in His written word, not a thing which we behold in nature

could exist ten seconds should that law cease to operate.

But, further, we can believe that He made us in His own image, able to look up to Him and to praise Him as our Author and Redeemer. We can will to surrender our will to His, and can feel assured that Christ's words are meant for us, too, " In my Father's house are many mansions; I go to prepare a place for you; and if I go and prepare a place for you, I will come again and receive you unto myself that where I am, there ye may be also." This means that, like Him, we shall enjoy the free range of the universe and of all the island universes, adapted no longer to one world but to all, endowed no longer with feeble locomotion but with the power to will, and, with the rapidity of thought, to pass from world to world. We shall discover that relativity holds good for that other existence, also; space and time are only relative terms, applicable to this world with its limitations. Then, seeing no longer as in a reflector, in riddles, but face to face, forever studying the works of God and learning infinitely more of His greatness, goodness and love, we can gloriously serve Him in the high and holy interests of His many universes.

Our respect for the statements of the Scripture passages quoted is increased, and our confidence in their truth is confirmed, when we come to know that every bit of light and heat, all the marvellous manifestations of electricity for the welfare of man and every atom of matter in the universes, all are possible only because they are obeying this law of circular and onward

movement—rotating on their axes and revolving around a centre. All these atoms, as we shall see later, are often compared by scientists to our solar system and to those stellar systems which, trillions in number within the range of the telescope and photographic plate, are all describing their cycles through space. One Wisdom made them all.

Everything in the heavens above is a pattern after which things on the earth have been formed. If we had the deuteroscopy to look deeply enough into the things about us, we could trace our way back to "the throne of the Almighty." But we have become dim of vision and have lost our way, and so we tread on the stars under our feet and wander amid the forces of nature as lost children crying for home. Yet God is opening our minds through the development of scientific thought; so we shall continue to make on every hand discoveries which remind us of Him and enlarge our conceptions of Him, and to establish our faith in His marvellous plan for us and in the laws by which, executing that plan, He leads us home.

If in our wills we coincide with that plan, and if we purpose to co-operate with the laws of our being as they are revealed to us in nature, in the Bible and in our own consciences, we shall not only fulfil our cycle here but shall also move onward toward God's end for us, as truly as the mighty spirals in the nebulæ in the heavens are progressing toward perfection and fulfilling their destiny—many of them, perhaps, in the formation of more suns and worlds.

What an exalted conception it gives us of our posi-

tion on earth to remember that the same circulatory forces which play about us and within us, and make life possible to us, cause gravitation which holds all worlds in space as they sweep in their orderly processions; and that these are also the forces which produce the cohesion of all particles of matter, giving the diamond its hardness. All chemical processes, whether in plant or laboratory or animal life, are simply atoms obeying the behest of the Creator in this circular and onward movement. And every material thing out of which the atoms are made, according to Kelvin and others, is due to the vortical motion of the ether.

The circular movement of which we partake in life is ever onward; we do not go back to the same place. The highest of all forms is the spiral, which from its nature is infinite. It is the circle infinitely continued. As we have already seen, we have magnificent displays of the spiral in the wonderful vortices of stars which sweep in spiral forms through space. The spiral, rather than the circle, is the emblem of eternity.

The tendency in nature to produce spiral forms is manifest in numerous ways. Take any number of univalve shells—such as the Stromb; a Winkle, the deadly enemy of the oyster; the Naticoid sea snail; a Trochid from the shores of the Mediterranean; a Petroceras, or scorpion shell; the Conus Literator; the long spiral Turritella or a Siliquaria—and you will notice that they are all more or less spirals, twisting from right to left; that is, if they were found in waters

north of the equator. If you find one which twists otherwise, or with the hands of a clock, it was doubtless formed in waters in the southern hemisphere.

It is interesting to note that among the plants in the vegetable kingdom which turn from right to left, or against the sun, are the bean vine, the hop, the ivy, the wistaria; among phenomena in the atmosphere, cyclones; among birds, the swallows and sailing birds; among fish, many schools of fish; among men, races over a race course; among games, " Fox and Geese " and the baseball diamond; among other things, turbine engines, the old horse-power sweeps, capstans on ships, the bore in rifle barrels. Persons who are lost in a forest wander in a spiral from right to left, and the knives and hats thrown and caught by conjurers take a like direction. Most trees have a twist from right to left. This results in producing lumber which must be planed with the grain, as all wood dressers realize.

This marked tendency in nature for things to turn from right to left, or against the sun, is doubtless due to the revolution of the earth from west to east. At the equator the motion eastward is 1,036 miles an hour, at 15° its velocity is 1,000; at latitude 30° it is 897 miles, at latitude 45° 732 miles and at 60° 518 miles; it diminishes uniformly until at the poles it is nothing.

The rotation of the earth has a tendency to carry everything with it. It is easier to go the way the world goes than in the opposite direction. Plants and animals, particularly when young and tender, grow

along the line of least resistance, which is opposite to the apparent motion of the sun.

The revolution of the earth on its axis, and the differences of temperature and density of the waters of the ocean, cause a constant circulation of these waters in vertical and horizontal directions. These currents are mighty rivers in the ocean, the most notable one of which is the Gulf Stream.

The ocean currents are marvellous in their effects on the winds, on climate and on vegetable and animal existences. Many volumes would need to be written to present adequately their origin, function and importance. Concerning them man's knowledge is still in its infancy. The study and control of them will some day effect great results in the life and destiny of man.

The hydrographic department of the United States navy has devoted much study to, and made many surveys of, these currents. One of their reports says: "The Gulf Stream is undoubtedly the greatest and mightiest of all terrestrial phenomena. There is a river in the ocean, its fountain in the Gulf of Mexico, its mouth in the Arctic Ocean; a current more rapid and conveying more heat than would a stream of molten iron the size and velocity of the Mississippi."

The late C. L. Riker reported: "Ninety billion cubic yards of water, at more than 75 degrees Fahrenheit, pass Cape Florida northward every hour, liberating more heat, in being cooled to 55 degrees, than could be produced by burning two million tons of coal every minute. It carries its waters northward, easily

distinguished from the surrounding ocean by its deep blue colour." Between Cape Florida and Bimini the Gulf Stream has a width of about forty miles and is about twelve hundred feet deep.

There is an Arctic current which sweeps down along the coast of Greenland out of Baffin Bay, and passes the coast of Labrador and Newfoundland, bearing with it vast fields of ice. This current attacks the Gulf Stream over the Great Banks, in a never-ending struggle for the mastery. The winds often hold the balance of power. The struggle ends in either cold or warm bands extending across the Banks. Part of this Arctic river, with its average temperature of thirty-two degrees, continues its attack even to the source of the Gulf Stream, where it passes between Bimini and Florida Cape, and goes beneath the stream, and even chills it in its very cradle in the Gulf of Mexico. If the Arctic current should gain complete ascendancy, it would transform the whole eastern coast of the United States into a land as desolate as Labrador.

The Gulf Stream like a mighty river of blessing sweeps steadily northward; it divides into different branches but in the main moves round the British Islands, through the North Sea, downward off the west coast of Europe and Africa, past the Canary Islands and westward across the Atlantic; then it divides, part entering the Caribbean Sea, the other great branch moving north past Cuba and on in a circular form past the Azores and again turning south and then west, encircling the Sargasso Sea, and ending in rips and eddies after having formed a mighty spiral.

Other stupendous rivers sweep in circular and spiral forms around the south Atlantic, Pacific and Indian Oceans. These and the spiral currents in the atmosphere are the greatest on earth, and remind us of those seen in the heavens.

We ourselves are very largely built after circular and spiral patterns. Not only our atoms, cells and red corpuscles, with our nervous and electrical forces, conform to this type, but the formation of the heart is an interesting illustration of the law of spiral growth. "That organ originates in a mass of pulsating cells, which gradually become hollow, giving the first form of the heart as a straight tube. This is the permanent form of the heart in many animals. When the organ is to be developed into a more complex form, its first step in the process, is a twisting, and finally it coils itself into a spiral form. And this fundamental form is retained in all its subsequent development."[1]

The spiral is the result of growth under resistance. Parts which grow freely show it well, as the horns of animals or the roots of seeds when made to germinate in water. The expanding tissue, compressed by its own resisting coat, wreathes itself into spiral curves. That a spiral is the direction which a body takes when moving under resistance may be seen by watching a bubble rising in the water or the sinking of a moderately heavy body through the water.

All our growth is against resistance, hence the spiral tendency in our physical life. Spiral sea shells devel-

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[1] James Hinton.

oped against resistance, the spiral ever enlarging. So all growth is the result of overcoming resistance. This principle holds true, from the muscles in the body and the heart and the cosmic matter in the heavens to our minds and spirits. We meet oppositions and bend around them, as the roots of a tree, advancing against resistance, twist around the opposition and onward press their way.

As the auger bores its way through the wood; as the latest snow-plow whirls the hard snow from the railway tracks; as the great sweepers remove dirt from our city streets; as the bullet is given its spinning motion when it leaves the gun, that it may overcome resistance and so go straight; so all physical, mental and moral growth proceeds against what seem almost insuperable obstacles. "As we look at the roots of a mighty tree, it appears to us as if they had thrust themselves with giant violence into the solid earth. But it is not so; they were led on gently, cell added to cell, softly as the dews descend, and the loosened earth made way."

We do not make our growth by crushing all opposing forces in our path nor by great noise and bluster like the tornado, but gently, persistently, we meet the oppositions, adjust ourselves to them, conquer them and go past them on our way toward our goal. We get down into the valley of humility, and then up on the mountain of exultation; contrasts ever. Obeying the laws of our being, the stars in their courses fight not against us, but for us.

Not alone do all the visible things of creation and

of our lives but the greatest event in history, the most stupendous transaction in the universe, reveals the same circular and onward movement.

The Creator, our Lord, came down to the lowest depths of our humanity and passed through the tomb, back to the heavens into intimate fellowship and immediate contact with the Father, completing the cycle typified in nature and necessary for our salvation. But it was also an onward movement. By that love and condescension our Lord reached a higher state of glory and blessedness than infinite wisdom and power alone could have given Him. Love brought Him down, carried Him on through the cycle of our salvation and took Him on to infinite heights of glory. The very nebulous vortices in the stars and all the atoms of creation and every thing everywhere are so many tongues proclaiming the goodness and mercy of God in Christ.

Somewhat as the mighty Gulf Stream sweeps round our Atlantic coasts, creating a balmy atmosphere and fructifying the continents, and coils into a gigantic spiral around the Sargossa Sea and finally wraps the Bermuda Islands in its embrace, so the Creator came down to us leaving benefactions on every hand as He moved forward, and at last enfolding us in the embrace of His love and mercy, transforms us from cold, desolate beings into beings whose verdure and fruitfulness harmonize with the glories of His creation and who, as intelligent beings, are able to fellowship with and praise Him above all created things, even outshining the glory of the stars.

Spiral motions tend to draw everything toward the centre. Mädler thought he had discovered the centre of gravitation of all created worlds to be the beautiful star Alcyone in the Pleiades. There is, however, a Centre of all the universes, and we gravitate about Him. We are drawn toward that Centre as we move onward, but, like Him, we must first come down into the valley of humility and repentance, and then by faith we can rise in Him to the heights of His own glory.

PART II

WIRELESS TELEGRAPHY; THE RADIO; INVISIBLE LIGHT, INAUDIBLE SOUNDS; TELEPATHY

VIII

DISCOVERY AND MYSTERY

THE progress of discovery and the improvements which have been made in electrical communication without wires during the past twenty-five years have been nothing less than marvellous. The predictions which at first were made regarding them seemed extravagant enough, but these have been more than realized.

Not only have messages by ether waves spanned the ocean and gone across continents, but they have encircled the globe, and in precisely five seconds. This, however, was done by relays. Two messages were sent from New York. One was forwarded from Marion, Massachusetts, and was intercepted at San Francisco. From there it was received across the Pacific at Saigon, French Indo China, whose operator sent it to Paris, France; and thence it went to New York. The eastward message was received at Paris, then at Malabar, Honolulu and New York. The difference in time in which the two messages encircled the earth on their 40,000 mile routes was only a half-second.

Had the energy and the wave lengths at the initial sending station in New York been sufficient, the messages would have encircled the globe, with no relaying, nearly seven and one-half times in one second. Some

of the waves, moving east, and others, moving west, would have met again in the operator's room, and been heard by him long before he could have lifted his finger from the key of his instrument. The first letter in the first word would have been heard after its trip around the world before the operator could begin forming the second word.

With a radio apparatus so powerful as that, the first word spoken into the microphone would travel around the world in both directions—in fact, in all directions —and be heard in the ear phones, in the room of the sender, before the second word could be uttered. The messages thus sent by ether waves travel with the speed of light—that is, 186,300 miles a second—or about seven and one-half times around the world in a single second.

While such a feat has not yet been accomplished, he would be doubtful indeed, who would not dare to predict that, as not only possible within a short time, but also that even more wonderful things will be done.

Already photographs are sent by this lightning express, and the time will come when one can speak to his friend halfway round the world and look into his face at the same time—both hear and see him, as he moves at a hundred miles or more in an aeroplane or speeds in a submarine at the bottom of the sea or is far down in a mine in the heart of the earth.

Along other lines no less astonishing, this ancient terror and now new servant is yet destined to perform its marvels. Hints of them are already witnessed in

the transmission of energy. Recently radio waves flashed across the ocean from Carnarvon, Wales, set off a powder flashlight, clicked a camera and made a photograph in the Grand Central Palace in New York.

It is now such a common occurrence for "listeners in," say at Los Angeles, to hear concerts or speeches in Boston that it ceases to be commented on as marvellous. But so it is, nevertheless; and the more it is studied, known and experimented with, the more it is a cause for wonderment.

When we stop to consider that the music of an oratorio and the eloquent words of an oration, sent thus by ether waves, pass through the walls and rooms of houses, and even through human bodies in their 3,000 mile journey, and that, had the hearers receiving instruments attuned to the right pitch, the 115,000,000 people in the whole country could have heard them at the same instant as they were received through the walls of their buildings, then we can better realize what a marvellous agent has been brought within our knowledge and control.

Though very much has been learned about this modern wizard of the ether during the past quarter of a century, the mysteries concerning it were never more profound than now. Some persons seem to be very much disturbed if they meet with mysteries, particularly if the mystery be concerning something religious. They have difficulty in believing things to be actual which they are utterly unable to understand. How can prayer be answered, and natural laws continue to operate? How can the Bible be a safe spiritual guide,

and be written by men such as we? Miracles must not be acknowledged as real, they are contrary to natural laws, above reason and comprehension. Explain the how of the incarnation, resurrection and ascension of Christ, and they will believe.

That is not our method in the use of the radio. There is not one thing about it the ultimate reason for which the users of it can understand. Furthermore, no scientist past or present can explain its mysteries. And what is true of this wonderful invention is true of most other things in nature. Every one is familiar with what we term an electric current, yet the current itself no one ever saw, felt, tasted, smelled or heard. It does not impress any of our senses. We know it only by certain of its effects. We do not know why there are two kinds of electricity nor why opposite kinds attract each other or similar kinds repel each other. No one knows why an electron at one time travels in one orbit, and then prefers another; nor why it leaps at one time from its orbit and not at another, nor why it emits light as it leaps.

The most profound scientists acknowledge that they do not know the final reasons for a single phenomenon. Their sounding-rod is still too short for the immensity of such abysses. We heat our homes, and use heat in a thousand other ways, without knowing anything of its essence. Well has Dr. Gustave LeBon stated: " If a physicist be asked what cause keeps together the molecules of a solid body—a bar of iron, for instance —he will reply that it is a force named cohesion. If he be further asked of what cohesion consists, he will

THE GREAT SPIRAL NEBULA IN TRIANGULUM

It is known as M 33, after C. Messier, the French astronomer, whose initial M, with accompanying number, is associated with the nebulae and star clusters in his famous list. Taken at Mount Wilson observatory, and used by permission. Exposure eight hours and thirty minutes, sixty-inch reflector. (*See page 112.*)

be obliged to answer that he has no idea. If we ask a chemist why certain bodies when brought together combine, he will say that it is by virtue of an unknown force called affinity, of which he can only verify effects. We would obtain similar answers on interrogating him about osmosis, crystallization, catalytic action, the action of diastasis, etc." We are profoundly ignorant of some forces of which we clearly discern the effects.

In the radio, and in all other scientific matters, we use forces, and obtain beneficent results from them, the nature of which forces are a mystery to us. We do not hesitate, however, to utilize them in order to produce results. By trial we have learned what they will do. The reason may come later, or it may never come.

The Great First Cause of all things, God, is the greatest of all mysteries, but He is also the solution of every mystery. Banish Him from science and from nature, and all becomes chaos as dark as brooded over the earth at first. But put Him behind nature and religion, and all is clear, reasonable, reliable and full of hope.

Now, as to the ether: It is almost universally conceded by scientists that there is an entity which fills all space and which acts as a medium for the propagation of light and all kindred radiant energy; this is termed the ether. Formerly it was called the luminiferous ether, for it was thought that only luminous or light waves were propagated through it.

The theory of ether is only a theory, but in no other way than by its use can many phenomena in light, heat,

and electricity be satisfactorily explained. The ether is supposed to be nonatomic, to possess a definite density and to be elastic. It cannot be detected by any of our senses. It fills all space, as far as the most distant star—out beyond the island universes in Andromeda, whence the light coming to us requires more than a million years to reach us.

The spaces between the molecules of material substances are supposed to be occupied by the ether. Hence it is that radio waves are able to penetrate and pass through material bodies. Very strange qualities are possessed by the ether. It is rarer than any known gas, and yet it is more rigid than steel, yet is able to transmit energy without loss from one part to another. Lord Kelvin wrote: "Of one thing we are sure—the reality and substantiality of the ether." The atmosphere practically ceases at 200 miles above the earth, and at 4,000 miles above the earth's surface its density is regarded as 10^{-126}. The density of the ether is calculated to be 2.6×10^{-24}, so that a mass of it the size of the earth would weigh only 1.7 pounds.

CHART OF WAVES

		Octaves	Vibrations	
Unexplored region.		(75)	491	Sextillion vibrations.
		(74)	245	"
		(73)	122.8	"
		(72)	61.44	"
		(71)	30.7	"
		(70)	15.36	"
New Rays		(69)	7.68	" — New Cosmic Rays from outer space announced by Millikan, (so hard that they penetrate six feet of lead, vibrating 10 million times that of ordinary light waves.)
Unknown.		(68)	3.84	"
		(67)	1.92	"
		(66)	960	Quintillion
		(65)	480	"
		(64)	240	"
Radium gamma waves.		(63)	120	" — Gamma rays of Radium.
		(62)	62	" " " " "
		(61)	31	" " " " "
		(60)	15	"
		(59)	7,824	Quadrillion
		(58)	3,912	"
		(57)	1,956	" — Extreme height of X-rays; 7½ billionth. Iron atoms, 1538 quadrillion
X-ray range		(56)	978	" — Calcium, 13 billionth inch; 888 quadrillion.
		(55)	489	"
		(54)	244.5	"
		(53)	122	"
		(52)	62	"
		(51)	30	" — X-rays, up to about 2 quintillion.
		(50)	15	"
		(49)	7.5	"
		(48)	3.8	"
Ultra violet. Range of Eye.		(47)	1.9	"
		(46)	956	Trillion: ultra violet rays, 750 to 1500 trillion.
		(45)	478	" — Light, red 434, orange 500, yellow 520, green 570, blue 634, indigo 690, violet 740 trillion vibrations per second.
		(44)	239	" — Highest heat sensation, 300 trillion, 39 millionth inches.
		(43)	119	Trillion
		(42)	59	"
		(41)	29	" — Lowest heat sensation, 20 trillion, 383 millionth inch.
		(40)	14	"
		(39)	7.4	"
		(38)	3.7	"
		(37)	1.8	" — Bolometer record; several octaves below color red.
Undiscovered waves.		(36)	934	billion
		(35)	467	"
		(34)	233	"
		(33)	116	"
		(32)	58	"
		(31)	29	"
		(30)	14.5	"
		(29)	7.2	"
		(28)	3.6	"
		(27)	1.8	"
		(26)	912	million
		(25)	456	" — Shortest electrical wave, 2½ inches, 480 million per second.
		(24)	228	" — Five-inch oscillator, 7 inches; 172 million per second.
		(23)	114	" — Large oscillator 1 foot; 100 million per second.
		(22)	57	"
		(21)	28.5	"
		(20)	14	" — Pint Leyden jar, 54 feet; 18 million.
		(19)	7	"
Range of hearing — Radio waves.		(18)	3.5	" — Limit of Radio electric waves.
		(17)	1,781	thousand
		(16)	890	"
		(15)	445	"
		(14)	222	"
		(13)	111	"
		(12)	55	" — Limit of hearing, air wave 1/5 inch.
		(11)	27	"
		(10)	13	" — Induction coil, 18 miles; 10,000 vibrations per second.
		(9)	6,960	Piccolo flute 2.95 inches; 4698 vibrations, d''' per second.
Piano waves		(8)	3,480	a''' Limit of piano music, high c''' 4176; a''' 3480, 4 inches minus.
		(7)	1,740	a''
		(6)	870	a'
		(5)	435	Concert pitch, A 2 ft. 7 in.; B 489.37; C 522 vibrations.
		(4)	217.5	261 middle C; D 293.62; E 326.75; F 348; G 391.5 per second.
		(3)	108.75	
		(2)	54.37	Electro-magnetic waves for lighting as low as 60 per second.
		(1)	27⅜	Lowest note on piano, 42 feet 3 inches, wave length.
			13.75	Lowest air vibration heard. Wave length, 83 feet, 7 inches.
		Octaves	Vibrations	

WAVE LENGTHS, AIR AND ETHER WAVES

(READ UPWARD)

IX

WAVES

IT is interesting to note the method employed by skilled boatmen out at sea when they desire to reach the shore when the breakers are rolling in upon it. They do not row in in a haphazard way, regardless of the waves. Should they attempt to do that, they would doubtless get into the trough of the breakers, and their boat would be filled and swamped. One who has had that experience even once will ever after remember it.

The water is more or less shallow where the breakers form. Before reaching these, experienced boatmen hold their boat in check until a long, large wave approaches them, and then they speed up the boat so that when the wave overtakes it they will be moving at about the same rate. Then, with the bow on the shore side of the wave and the stern on the other, the boatmen strike the water with their oars, or move forward with their engine, at the same rate as the wave is travelling; when the wave becomes a rolling breaker the boat, poised on its crest, rolls along with it to the shore, and the men leap out high and dry upon the land.

That method is similar to the one by which we telegraph or telephone through space without wires. We

put the message, so to speak, on the crest of waves, and they speed forward to their destination.

There are many kinds of waves. We are familiar with water waves, caused by our casting a stone into the water or by the winds. If the stone be a small one, the waves will be small or short waves; if it be large, they will be larger or longer. In whatever medium waves may be produced they move in circles away from their source or centre. A child watching waves race past him has the impression that the water is rushing onward toward the shore. This is true to only a limited extent. A board on the water is seen to rise and fall with the waves, but the impulse imparted to the water by the wind moves onward toward the shore.

If a long rope be fastened at one end near the floor, and if the other end be held in the hand and the rope be moved quickly up and down, it will appear to run in waves away from the hand. The impulse imparted to the rope by the hand runs through it in the form of waves.

There are two motions to all waves, the up and down or transverse, and the longitudinal or straight onward. Waves in a gas or in the air push along the particles of the gas parallel to the direction of the wave propagation. So such waves—those of sound, for example—are to and fro motions along the line of propagation, or are longitudinal. The energy which passes through an elastic solid, like the rope or the ether, produces waves which are transverse or up and down, as well as longitudinal. There is no progressive motion of

the medium itself, whether it be the rope or the ether, as there is with the air in sound waves.

The longitudinal rate of long ocean waves is about eighty-eight feet a second, and that of small ripples is from four inches to three feet a second. Sound waves in the air have a velocity of about 1,100 feet a second. In freezing temperature they travel approximately 1,090 feet, with two feet less for each degree below that and two feet a second more as the temperature rises above freezing. The rate in water is four times greater than in air, twelve times greater in wood and sixteen times greater in steel. In air it is about twelve miles a minute, and so it would require thirty-three hours, or two nights and a day, to travel around the earth.

The waves of radiant energy, which include electric and light waves, heat and ultra violet light, travel at the rate of 186,300 miles a second.

The to and fro vibrations of sound waves vary from about 13 to 50,000 or 60,000 per second. The first A on the piano is caused by a vibration of $27\frac{3}{16}$ a second; middle A by 435, and the highest A by 3,480, and the highest C by 4,176 vibrations. Musical tones are from 40 to 4,000. The piccolo flute produces a note which vibrates 4,698 times. The average range of the human voice in man is from 190 to 678 vibrations a second. Woman's voice vibrates about twice as fast; that is, from 572 times to 1,606 times a second. Caruso's voice, according to Dr. William Lloyd of London, when singing C sharp reached 550 vibrations a second, which was regarded as unusual. Some voices

have a phenomenal range. It is said that Michael Prita's voice compassed five octaves and went two octaves lower than the deepest note which can be produced on the violin. He rendered upper A corresponding to 1,740 vibrations a second, which was one note higher than the highest sung by Patti.

The range of sound vibrations covered by the piano is from 27 3/16 to 4,176, or about 7½ octaves. The average range of the human ear for the detecting of sound waves is from 13, the lowest, to 25,000 per second, but some aurists have discovered those who can hear even 60,000 vibrations a second.

Above that number the energy passes through the ether as a medium, and we term such vibrations electric or Hertzian waves, infra red or dark light; light waves; ultra violet; X-rays, and gamma rays, from radium and other radioactive substances.

As has been stated in a previous chapter, all the vibrations with which we are familiar in physics cover sixty-nine octaves, and those not yet detected and controlled cover very many more; according to some estimates, not less than 300 billion octaves.

All these vibrations, including those of the molecules and atoms of all material things on earth and the ether vibrations which pour in upon our atmosphere from the countless suns in the heavens, are of a musical character. They are never a confused and discordant mass but are rhythmical and harmonious, as we can see from the symmetrical and exquisite forms in which they arrange themselves in matter when they take visible shape in frost and in

crystallizations and in the ferns and flowers of the Chladni figures.

Were our ears as sensitive to vibrations as are our eyes, we should be able to hear the forty-five or more octaves. All the beautiful colours of earth and sky would be heard, together with the strains which flood the earth from the stars. According to Job 38:7, the morning stars sing; they send forth their varied tones in every conceivable hue and tint of colour. The " music of the spheres " is more than a poetic fancy.

An unknown writer has beautifully delineated the inaudible music of nature and the ethereal harmonies radiated from the stars:

" Hast thou not heard it, the universal music,
The throbbing harmony, the old eternal rhyme,
In the wild billows roaring,
In the mad torrent pouring,
And keeping with the stars its beat and march sublime?
Hast thou not heard it when the night was silent,
And nothing stirred but winds amid the trees,
And the star-orbs, strings of harps celestial,
Seemed quivering to the rush of melodies?

" If in thy soul there pulse not some faint responsive echo
Of that supernal everlasting hymn,
Thou art of the low earth lowly,
Or livest life unholy,
Or dullest spiritual sense by carnal grossness dim.
Hear it, O poet, hear it! O preacher, give it welcome!
O loving heart, receive it, deep in thine inmost core,
The harmony of angels—glory, forever glory,
Glory and peace and joy and love forevermore."

We have already stated that it has been estimated that the sum total of all vibrations in nature would

comprise 300 billion octaves. If this be at all within the truth, or even partially so, we can see that we live and move in a mighty sea of such wave motions, which surge about us and through us and to the presence of which we are almost wholly oblivious.

We are so constructed that our physical senses are able to respond to only about twelve and one-half octaves, eleven and one-half octaves of sound through the ear and one octave of light waves through the eye. All the others, millions of times more than we can hear or see, are either below or above the range of our ear and our eye. Of the sixty-nine octaves with which we are experimenting in the physics of sound, light and electricity, we are made more or less conversant with the forty-four octaves which lie beyond the range of our senses, by means of the wireless inventions, the bolometer and the atomic response made by such substances as calcium sulphide and sulphide of zinc, in the violet region of the spectrum. These syntonic vibrations of the atoms will be further considered in the chapter on radium.

Bryant reminds us that

> All that tread
> The globe are but a handful to the tribes,
> That slumber in its bosom.

Likewise we would say that, of all the forces which pulsate within and around us, that which we know is but a small fraction of the whole; vast continents lie beyond us, waiting for us to explore and take possession of them, whereas as yet we have barely

encompassed a few garden plots. We have dipped our small receptacle into the sea, and its half-filled contents are very wonderful, but the boundless and invisible ocean lies beyond us. Some day, after the three score years and ten, we shall embark upon it. It will be a voyage of eternal discovery, beside which Darwin's voyage of the Beagle will be tame indeed.

As to our present knowledge of the forces which play about us, we are much like a man shut away in a dark cave. Amid our darkness there are five tiny openings, like pin holes, and these we name the five senses, hearing, seeing, smelling, tasting and feeling. As we perceive something of what lies beyond by what comes to us through the pin holes, we exclaim: "How wonderful!" And so it is, for it has brought us into touch with a world exterior to us. We know that it is a real world, and as we magnify the pin-hole energy forcing its way into our prison house through the tiny openings our astonishment increases. But if the little of which we have become cognizant in our cavern-home is so marvellous, what will it be when we step out of that restricted and obscure abode and behold the whole horizon of God's creation!

Others, who have preceded us, respond to it all. No longer do they depend upon a nervous organism which extends only an arm's length from them and by means of which they are made sensible of what God has made. No longer must they wait until the beams of light and of harmony crowd into the tiny apertures of the body and touch the soul. The whole illimitable ether of space has become their nervous organism; it is as easy

for them to see and touch Rigel or the Island Universes as it is for us to lay the hand upon the arm of a friend and behold the smile on his face.

All along the pathway of life, nature points with many a finger to what lies out of sight and beyond her; if we divine her meaning, read aright her symbols and follow them, we shall one day see face to face, and know as we are now being known.

X

PRODUCING WAVES

IF a stone be cast into the water, waves are produced; if an object be struck or a gun fired, sound waves are produced. So if we light a match, we create light or ether waves. If an electric current be passed through an induction coil—such a coil, for example, as is used on all automobiles—a spark will leap between the two terminals of the coil, and this creates an electric wave. It is like throwing a stone into the ether. For a long time the induction coil was the only transmitter of electric waves. Such a coil transforms an electric current of low voltage and comparatively large current or amperage into an alternating current of high voltage and small amperage. In such a case it would be called a " step-up " transformer. It may also be used in a receiving set as a " step-down " transformer, in which case the current is transformed from one of high voltage and small amperage to a current of low voltage and larger amperage.

Such an instrument is called a spark transmitter; waves emitted from an arc, from high frequency alternators or from a vacuum tube set are termed continuous wave transmitters. The operating principles, however, are practically the same.

In all cases of transmitting without wires, whether

it be in radio telegraphy or in radio telephony, the current, however generated—whether by battery, storage battery or dynamo—must first be converted into one of high frequency. The method generally employed is the use of an alternating transformer, which receives the current from an alternating current generator and steps it up into a high frequency current. A key is pressed, and the current, being at high tension, leaps between the two terminals of the transformer, or rotary spark gap, and a wave is created. This falls upon the antenna attached to one terminal of the spark gap and is radiated into the ether of space.

If the instrument be a radio telegraphic one, by alternately pressing and releasing the key, the dots and dashes of the international Morse code are formed. If it be a radio telephone, an ordinary telephone mouthpiece or a carbon microphone transmitter receives the impression of the voice, instead of that of a finger, as in radio telegraphy, and this closes the circuit and transforms the sound wave into an electric wave of high frequency; this wave is radiated from the antenna, as in the case of radio telegraphy.

The sound waves, say 1,000 vibrations a second, are transformed into electromagnetic waves having frequencies from 10,000 to 3,000,000 a second. Whereas the sound waves travel at about 1,100 feet per second, these travel with the speed of light, 186,300 miles a second. In radio communication long waves travel farthest, and long antennæ are used to radiate them. The sound of a flute played behind a building is less perceptible than that of a trombone, because the

waves produced by the trombone are longer than those produced by the flute, and so pass more readily around the building. Electric waves are much longer than light waves, and consequently they pass round large obstacles, but light waves are stopped short by objects no larger than a hair.

The usual wave length used by the Annapolis 500-kilowatt arc station is about 17,100 metres, which means that the wave lengths are of more than ten miles. A station working in 200 metres has a wave length of one-eighth of a mile, or 656 feet. A wave of only an eighth of a mile would pass around quite an extensive corner, though light waves, which measure only from one-thirty-eight thousandth to one-sixty thousandth of an inch, would be barred by a small obstacle.

Stations with energy represented by 500 kilowatts and upwards create waves which doubtless, under favourable circumstances, pass around obstacles so as to circumfer the earth.

XI

RECEIVERS OF WAVES

THERE are numerous receivers for waves. The ear is a very wonderful receiver for about eleven and one-half octaves of sound waves, compassing from 13 to 50,000 or more vibrations. It is also an exceedingly delicate receiver. According to the measurements by Dren, the ear can be affected by waves of the order of about 5^{-23} watts, which, expressed decimally, is .00,000,000,000,000,-000,000,005 of a watt.

The eye, also, is a marvellous receiver of ether waves, having a compass of one octave of vibrations. More than 700 trillion vibrations of violet light can enter the eye in one second. At this prodigious rate, the rods and cones below the retina are hit by the waves of light and respond to them with perfect images sent over the optic nerves to the brain; and this process is continuously duplicated, not for a few seconds but for hours at a time. No audio receivers devised by man can approach the eye and ear as sensitive receivers of vibrations. But both these organs are limited in range, and are supplemented by the inventions in radio telegraphy and telephony. If our eyes could react to the long electromagnetic waves of ether, none but

blind men would have any need for wireless receiving sets.

The bolometer, invented by the great physicist, Professor Langley, is another receiver of waves of radiant energy. Its sensitive working part is an almost microscopic blackened platinum wire, a hundredth of a millimetre in thickness. Its effectiveness as a measurer or detector of heat radiations is based on the fact that heating a conducting body in which a current of electricity is passing increases its electrical resistance. If a ray of light, say from a fixed star, falls upon the platinum wire, the resistance of the wire to the passing current rises, and the galvinometer needle connected in the circuit is deflected, and thus the amount of the heat from the star is measured. This instrument is able to detect one hundred-millionth of a Centigrade degree and has extended the invisible spectrum in the infra-red region to a length twelve times that of the visible part.

Among the many detectors of waves of radiant energy are the photographic plate, the electrical spark gap, as in the relay, the telephone, the electrometer, vacuum or electron tubes, metal filings, carbon granules and many minerals.

Elaborate apparatus is not necessary for the reception of electro-magnetic ether waves, as in radio telephony. Two dissimilar solid substances, metals or minerals cannot be brought into contact without causing a measurable flow of electricity to pass between them. A piece of metallic silicon, or carbon and native or artificial mineral crystals—as galena, iron pyrites,

molybdenite, bornite, chalcopyrite, zincite or carborundum—all are detectors when they have the point of a needle or pin in contact with them.

If the point of a pin rest upon a piece of metallic silicon, which is commonly the product of electric furnaces, and these two be attached to the wires of a telephone ear piece, to the aerial and to the ground, then when the high frequency waves from a radio sending station fall upon the wire of the aerial these impulses are manifest at the point of contact of the pin and silicon and, through the telephone, are converted into audible waves and are heard in the ear piece.

This is the simplest form of radio telephonic receiver, and even yet it is useful in field work in emergencies. More elaborate ones have been devised, and are used in order to reach greater distances by being able to detect feeble waves, to amplify them and to tune the receiver so that it will respond to waves of varying lengths. Besides, crystal detectors easily lose their sensitiveness; a touch or strong static or use renders them ineffective.

But, however elaborate they may be, even the best electron tube sets are all based upon one principle, that of the balance. It is well known that anything in a state of equilibrium is easily moved. For example, a stick laid across an open knife blade may be made to rest there exactly balanced. But even a breath is sufficient to overcome this state of equilibrium and to cause one end or the other to fall. This we might term a mechanical balance.

The pulse glass is another sensitive balance. A glass tube has a bulb at each end from which the air has been partially exhausted. A coloured liquid partly fills the bulbs. When one bulb is grasped in the hand, the liquid is seen to rush up into and pulsate in the other bulb. The air forming the partial vacuum in the bulb held in the hand is so sensitive to the warmth of the hand that it expands, and forces the liquid up into the other bulb, where it is seen to be in a state of vigorous ebullition. This is a thermal balance.

A carbon microphone, an acousticon or an ordinary telephone, may be so adjusted as to form an acoustic balance. When the current is in the circuit, if the ear piece be brought near to the receiver, or vice versa, a whistling sound is heard. The tone of this may be changed, raised or lowered by moving it nearer to or farther from the receiver. And places may be found, by moving it slowly back and forth, where silence ensues, because a node in the waves has been located. The waves of the room or surrounding atmosphere may be thus caught up and sent over the telephone line to the central station and back into the room again. These waves are often confused and unpleasant in the ear of the operator.

If the ear piece be placed under a horn, and the receiver placed a short way from it, a delicate state of equilibrium can be formed. Then, standing at some distance, if one calls a note of the right pitch, or whistles it, the instrument will begin to sing, and will continue until at a clap of the hands or the uttering of a discordant note the singing instantly ceases. This

balance is so delicate that even a whisper may be sufficient to overcome the equilibrium and start the singing.

A selenium cell may be so connected in an electric circuit that a delicate light balance is constituted. In such a circuit the selenium offers so much resistance to an electric current, say 27,000 ohms in a certain sized cell, that the current cannot flow through the circuit. But hold a lighted match near the selenium, or let a beam of light fall upon it; immediately the resistance falls to 7,000 ohms, a loss of 20,000, and the current passes in the circuit and the telephone bell in the circuit or the door bell rings. It ceases immediately, however, on the removal of the light rays from the selenium. In this case a condition of equilibrium exists in the circuit until the light waves fall upon the selenium, and then the state of balance ceases and the current operates—which means that the number of electrons flowing through the selenium has been decidedly accelerated.

Very similar to the mechanical, thermal and acoustic balances mentioned above is the electric balance by means of which we have radio telegraphy and radio telephony. In this case the balance in the electric circuit is constituted by means of the detector, whether it be one of the many minerals, a coherer composed of nickel and silver filings or an electron vacuum tube. And the finger which touches this balance and overcomes the state of equilibrium is the incoming electric wave.

The electron tube is thus far the most sensitive

detector known. It is valuable also because it can be used to generate, to amplify and to moderate electric oscillations. It closely resembles a ten-watt incandescent lamp. Within it may be seen a filament, at some distance from this a metal plate and between the two a wire or grid. When the current lights the bulb streams of electrons are shot from the filament and fall upon the plate. This latter has a tendency to become overcharged with the billions of negative electrons falling upon it each second, in which case they incline to turn back to the filament which was depleted by their departure. This would mean a going and coming or confusion; to avoid it, the grid is placed between the filament and the plate, in the path of the electrons, to intercept the deserters, and so the army is kept on the move in one direction.

This state of harmony or equilibrium is continued until oscillating radio waves begin to come down the aerial and fall upon the sensitive spot of all the tube—the army of marching electrons—when there is a sudden flutter among them. The invader which smote them was very feeble indeed, for it has travelled perhaps a thousand miles, but, feeble though it be, when it is thrust onward through another tube it is greatly reinforced or amplified—becomes a million, so to speak. Then it is toned down from its lofty racket among the millions of oscillations, and becomes transformed into one of the hundreds, is audible in the telephone, or loud speaker and is recognized as a song or speech from afar.

The electric oscillations entering the tube must be

amplified, for they are very feeble. But the amplified electric vibrations are too rapid by far for the ear to detect them—from 10,000 to 3,000,000 per second—and so they are transformed into audio-frequency waves, which vibrate at a rate of only a few hundred per second.

XII

THE LAW OF RESONANCE

THE method is most interesting by which the receiving apparatus is so adjusted to the length of waves sent out by the transmitting apparatus that there shall be instant and perfect response. It is through a process of tuning.

Everything has its keynote; this is because all objects vibrate. There is not an atom or a molecule anywhere but vibrates as it sweeps onward. All things when in a normal condition are in state of equilibrium, and we have noticed that things in equilibrium are easily moved.

A piano is an apt illustration. Press down one of the keys very gently, so that the hammer does not strike the wire and yet lifts the felt. Now the wire is in a state of equilibrium and is easily moved. Strike the key an octave higher, and immediately release it so that the felt will drop down upon it and stop its vibration. You hear the response of the one being held down. It sounds the same note as the one struck, because the wire vibrates in segments. But reverse the process, pressing down the higher key and striking the lower one, and you hear the higher one respond, but an octave higher than the note you struck. In this man-

ner you can obtain response two or three octaves away.

If the note sounded was an A and you try to obtain response from a B or C, you find only silence. They are out of harmony. The waves of one wire, say middle A vibrating 435 times a second, fall upon the one vibrating 870 times a second; and every second vibration of the higher one, it receives an impact from the lower one, and soon it sounds the same note as its pusher, but an octave higher. Put your foot on the pedal, lifting all the felts from the wires, and call into the piano; all the wires in unison with your voice respond in the same key.

A violin held to the ear near an open piano, when a key is struck, responds with a like tone. The two are in accord.

If two clocks hung on the wall have the same length of pendulum, the ticking of one will start the other—only, however, when the swing of the pendulums in both is timed alike.

Different pieces of bric-à-brac will often respond when a strong note from a cornet is sounded near by.

An acquaintance of the author was a cornetist. He noticed that when he blew B on the cornet, the spiral gong in the clock was agitated. Then he blew B flat, and the spiral leaped around the pendulum and stopped the clock. This he often repeated.

Two tuning forks with the same vibratory rate are mounted upon resonating boxes. One is placed on a table, and the other is held in the hand near by. If the fork in the hand be struck, and then grasped to

stop its vibrating, the other will be heard responding. Under favourable conditions this response can be heard by a large audience when the forks are twelve or more feet apart.

A small coin attached by wax to a prong of the fork on the table lessens its rate of vibration and throws it out of unison with the other fork, and there is no response. Remove the coin, and it responds as before. The reason for this response is plain. The first wave from the fork in the hand fell upon the tine of the other and moved it a trifle. When the tines returned and were ready to move forward again another impulse from the fork in the hand gave them one more tiny push, and these impacts were sufficiently multiplied in a few seconds to move the tines of the responding fork through an amplitude wide enough to make a tone loud enough for a large audience to hear it.

Every radio transmission set has its keynote. This note is of a definite and appreciable pitch, so that operators of receiving sets soon come to recognize it, very much as they recognize the voice of a friend. Receiving sets also have their keynotes, but the keynote of a set can be readily changed so that the instruments will be in tune with, or synchronize with, the waves sent out by different stations. To do this they must frequently change their keynote.

The operations of this law of resonance are far-reaching. Loose-leaded church windows are often heard vibrating a response when certain notes are sounded on the church organ. The notes of a powerful singer not infrequently accomplish the same results.

There is a commonly repeated statement by physicists that when the first iron bridge was built in England, at Colebrook Dale, a man asserted that he could "fiddle it down." He was bidden to try it. After a considerable time he succeeded in getting its keynote with his violin, and then it began to sway, to such an extent that he was begged to desist. It is currently reported also that the Broughton bridge fell under the tramp of sixty men who were marching in unison over it. Hence the sign which is sometimes displayed: "Bodies of men marching across this bridge must break step."

The chemical explosive tri-nitro-toluol, popularly known as TNT, is a striking illustration of how the atoms of a body may refuse to partake of the motion of powerful waves which are in dissonance with their own rate of vibration, but respond instantly to those waves whose periods synchronize with their own. This is true also of other organic nitrate explosives. TNT is insensitive to ordinary shocks. "A riflle bullet can be fired through a case of it without setting it off, and if lighted with a match it burns quietly. The amazing thing about these modern explosives is the way they will stand banging about and burning, and yet the terrific violence with which they blow up when shaken by an explosive wave of a particular velocity, like that of a fulminating cap." [1]

The weight of a dog on a bridge is insignificant, yet if a small dog trotting across a bridge chances to

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[1] *Creative Chemistry,* Slosson.

time his motions so that they are in unison with the vibratory rate of the bridge, he will cause it to sway as if an elephant were crossing.

As the writer was once about to speak in an auditorium in Saratoga Springs, he noticed a gong in the rear hallway. He tapped it, to get its keynote, and then stepped away and called that note; the gong sounded. Two little girls stood watching. One said: "I know what you have; there is a man in there." The other quickly ran behind, looked into the gong, and said: "No, he has no man there." Then she tapped the gong and stood back and called, but the gong refused to sound. Then it was explained to her that she did not call the right note. "Call like this," and the note being sounded, the gong gave its response.

One day a daughter in our family called to her sister, who was in another room, in a very shrill key, and we all heard a cut-glass dish on the buffet ringing response. She was told that she had gotten its keynote, and was bidden to call again. She did so, but she dropped down half a tone or so, and there was no response. When she called as at first, it rang again. This she was able to do a dozen feet away. At last she called the note about a foot from it. It rang so loudly that we touched it, as we grasped the vibrating tuning fork, to stop its vibration. We explained, to her astonishment, that she might break it. After this incident, all the cut-glass dishes, the shades over the gas jets and numerous other objects were made to reveal their secret tones. One of the unusual events was the breaking of a gas lamp chimney by working a

typewriter. The stroke of the hammer on the machine is produced by a pressure on the keys which releases a spring, and this causes the stroke always to be uniform. When a fresh ribbon had been put on, and the tension on the spring had been lessened to secure a lighter stroke, by chance this change got the keynote of the lamp chimney. As the waves from the typewriter fell upon it, it began to vibrate, and this released the strain under which it was made, and it was shivered to pieces.

In the same way any singer with a strong voice can call and sustain the note of a thin wineglass, near to it, and cause it to vibrate until it breaks. Caruso frequently did so.

This principle has been known for many centuries. A statement in the Talmud reads thus: "These are the words of the master, If a horse by neighing, or an ass by braying, break a vessel, the owner shall pay half the price. If a cock shall put his head into a vessel, and break it by his crowing, the owner must pay the whole price."

An amusing couplet runs as follows:

I have a donkey kind and good,
And in the autumn fair,
When I go nutting to the wood,
I ride my donkey there.

His voice it is so strong and free
It quite alarms the town,
And when he brays beneath a tree
The nuts come crashing down.

Muleteers in the high Alps muffle the bells on their

mules, lest the tinkling of the bells cause an avalanche.

Concerning the chamois hunters in the Alps, Rogers says:

> From rock to rock, with giant bound,
> High on their iron poles they pass,
> Mute, lest the air convulsed with sound,
> Rend from above the frozen mass.

All experienced mountain guides caution against loud calls or the firing of a pistol, for the same reason. The possibility of producing an avalanche by such feeble forces is realized after a little consideration. The vast masses of snow, ice and rocks hang on the mountain side, upheld by projecting rocks, while gravitation is pulling them downward. These two forces, the upward pressure and the downward pull, are in a state of equilibrium. The right note sounded overcomes that state of balance and precipitates the avalanche.

It is said that experienced marine engineers learn the keynote of the hull of the ship and the vibratory rate of the engines, and arrange things so that these shall not coincide. Otherwise, the vibrations of the engines would cause undesirable motions of the ship. For the same reason companion turbine engines are run at different rates of speed, so that the numerous blades will not be broken.

Many years ago Dr. F. N. Peloubet in his *Sunday School Notes,* said that there was a mill in Lowell, Massachusetts, whose keynote was such that when the engine was running at a certain rate the building would

shake so that it would nearly empty a pail of water standing on the floor. But if the rate of the engine were changed, a pail nearly level full of water could be left on the floor undisturbed.

The Rev. Dr. Van Ess, for many years pastor of a church in Ridgewood, New Jersey, stated to the author that his church edifice, situated near the railroad, was caused to vibrate unpleasantly when a certain train, about noon each day, blew its whistle near the building on approaching the station. The congregation had been unable to keep the plaster under the gallery on that side of the building from falling, and had finally had to replace it with a metal ceiling. No other whistle on any train seemed to disturb the building.

One day when passing a fine brick church, well known to us, we were not a little surprised to see several masons on the upper corner of the chapel pulling the bricks out of a considerable portion of it preparatory to relaying them. On inquiry we were told that the boys who had been using the room next to those bricks, by their rough behaviour were tearing the building down. We knew, however, that for twenty years or more the room had been used just as vigorously by other boys and had shown no signs of disintegration. The fact is that for a year or so a boys' fife and drum corps had been practicing in that room. The boys had learned one tune fairly well, and while passing we had often heard them play it, as they marched about the room, keeping time with the music. Their one tune continuously played, together with their tread keeping time with it, had done the damage. The

young musicians later became more skilled, and their tunes became more diversified. Now, though the vigour with which they enjoy good times is not abated, after a number of years the building shows no signs of going to pieces.

It is stated in Joshua, chapter 6, that the priests of the Hebrews, once a day for six days, marched around Jericho blowing their rams' horns, and that on the seventh day they marched around the city seven times, blowing their blasts. As they stood in their places and blew one long blast, and all the people shouted a great shout—probably in unison with the blasts of the trumpets—the wall fell. We have here vigorous vibrations, at certain definite intervals, and then on the last day, these seven times repeated with accumulative effect, together with the long sustained blast, and the shouts all directed against the wall. It is not surprising, then, that it is often suggested that the law of resonance was taken advantage of on this occasion, perhaps unwittingly, and wrought the ruin of the wall; its operation in numerous other instances has been destructive of large structures.

The human body is constructed in harmony with, and operates according to, this law. In the chapter on the praise in nature, page 75, we have seen how the ear, by means of the organ of Corti with its 24,000 cords, and the eye with its 8,000,000 or more rods and cones in the bacillary membrane, respond to the vibrations of the air and of the ether, and enable us to hear and to see—and only because they are in tune with the waves of sound and light. To be out of tune were to

be deaf and blind. The retina or the optic nerve can no more see than the end of the finger. The blind spot in the eye is the place where the optic nerve enters it through the retina. It is the musical response of the rods and cones to the waves of ether which enables us to hear, as it is the musical response of the cords of Corti to the waves of the air which enables us to hear.

Each person, also, has his keynote. This, fortunately, can be changed, as truly as we change the keynote of radio instruments. When Saul was depressed and his note was discordant, out of harmony with that which makes for health and sound reasoning, David played skilfully on his harp before him, and Saul's tone was raised, and he became rational. This incident illustrates how we naturally resonate with musical vibrations.

The therapeutic value of carefully chosen music has long been known; numerous skilled physicians have testified to its healing and curative virtues. This is not at all surprising, when we consider that the body is constructed on the principle of an intricate and elaborate musical instrument. All the sensory impulses pass over the nerves in the form of waves at the rate of 100 to 300 feet in a second. The action of the heart is rhythmical; the ear and the eye, as we have seen, are most wonderful musical instruments, vastly more delicate in their syntonic response than any radio detectors ever invented by man. Every cell in the body has capacity for vibratory response, and hence it is no uncommon experience for one to feel the thrill of musical tones pass over him from head to foot.

There are the best of reasons why we should develop the musical capacities with which we are endowed. The pleasurable experiences resulting from music have high therapeutic values, promote digestive and metabolic processes, strengthen the reasoning faculties and elevate the moral tone. It is not surprising that in this excitable age, in which our nerves are kept at high tension, nervous disorders should so largely predominate and should show an alarming increase in neurotic patients in our hospitals. Music, wisely chosen, is sedative in its effects; or it may be exciting and depressing. Skilled physicians in the treatment of mental derangements generally recognize the value of music, chosen with careful discrimination. To those who are interested in the subject we commend the fine chapter on Musico-Therapy in Edwards' book, *God and Music.*

It is a frequent occurrence for a dog to howl when he hears a certain church bell or a particular steam whistle. A friend has a dog which he takes by the fore paws, and begins to run up the musical scale. When he reaches a certain note and prolongs it, the dog raises his head and howls in the same key. The dog, having his particular keynote, feels a peculiar thrill pass over him, and gives vent to his feelings in a howl.

A well known clergyman of New York City told the author that he and his wife were descending a deep mine in Europe. As they stepped from the lift the compressed air which worked the drills, rushing out of the pipes, produced a powerful note of a certain

pitch which was so painful to his wife that they hurried her at once out of the mine. None of the others felt any unpleasant sensation.

Our sensitive little granddaughter, Gertrude Tyndall Mould, at the age of about a year wept when the victrola was regulated so that it played a song in a modulated tone; but she was at once relieved when the instrument was run at a cheering speed. A friend's infant son sat on the floor by his mother. When she sang in the minor key the child wept.

A cultured teacher with many years' experience was returning from California, and visited the Yosemite Valley. When she beheld the rainbow caused by the sunlight falling upon the spray from the falls, the sight of a certain shade of violet caused her instantly to weep, she knew not why. Another, with very delicate sensibilities, feels a peculiar fascination in a certain shade of a pink rose.

A friend whose attention was called, in an address in England, to the phenomena in the laws of resonance wrote of several authentic cases in which people had the faculty of realizing shapes and colours when sounds were heard, the colour varying with the temperament of the listeners. "One blind woman in Bristol could tell colours by touch; red felt hot, violet least warm."

The centres of sight, hearing and feeling are closely associated in the brain, so it is not at all astonishing that the agitations of the cells in one centre excite synchronous responses in other brain centres.

It was stated in *The Popular Science Monthly,* No-

vember, 1922, that the young son of Professor O. F. Curtis of Cornell University, when he beheld a brilliant rainbow, exclaimed: "A song, a song!" He would pick out the colours he saw on a colour chart when different musical notes were struck. He was accustomed to describe certain musical tones as white, red, yellow or blue.

Shakespeare intuitively felt the response of the soul to the vibrations in nature, as is indicated by the familiar quotation from the Merchant of Venice:

"Soft stillness and the night
Become the touches or sweet harmony.
Sit, Jessica! Look how the floor of heaven is thick inlaid
with patines of bright gold.
There's not the smallest orb which thou beholdest
But in his motion like an angel sings,
Still choiring to the young-eyed cherubims;
Such harmony is in immortal souls;
But while this muddy vesture of decay
Doth grossly close us in, we cannot hear it."

Sir Arthur Sullivan expresses a similar thought in his "Lost Chord," wherein he describes one as hearing, in a soul-moving strain, a "grand Amen," and as feeling he can never be content until he hears it again —if not on earth, then in heaven.

The human mind reveals that within it the same law of resonance operates. One meets a stranger and synchronizes with him at once—"love at first sight;" but another person, though of equally good reputation and noble character, may produce a repellent feeling. Their keynotes are different.

He is fortunate who learns to control his keynote,

and who needs no David to play skilfully on the harp to aid him in doing it. He learns to resonate with those whose natures are diverse from his own and also with his business or profession, although for the present they may have many annoyances. He meets his business associates with confidence, for sympathy, *συμπαθειν*—a feeling likewise—nestles beneath his exterior. He attracts instead of repelling, and so succeeds where others fail.

Brain cells are ether wave transmitters. Their agitations send not only impulses over the sensor nerves but waves into the ether; and other brain cells, in a state of delicate equilibrium, which are attuned to the same vibratory rate, can and do unquestionably respond to them. This process we term telepathy. Though there are continents in this realm yet waiting to be explored, enough has already been learned to make us perfectly certain that here we deal with facts as real, and evidences as scientific, as any known in radio telegraphy or radio telephony. And the time will come when what are now exceptional cases will be regarded as common occurrences, very similar to what we have witnessed in the rapid spread of radio communication.

> When soul with soul vibrates in perfect tune,
> The waves etheric scorn both word and space.
> Deep as the universe its mystic rune,
> Though eyes gaze not on the beloved face.
> Whose potent will but God's has power to stay;
> What shall forbid, and who shall say them nay?[2]

[2] Cornelia Minor Arnold.

It would require a larger volume than this adequately to present the reality and importance of the subject of telepathy. Many books deal with it; some, it is to be regretted, chiefly cite cases which border on the uncanny or which lie beyond the human and practical. The atmosphere will be decidedly clarified when it is understood that for brain cells and delicately balanced nervous organisms to respond to those of like kind is as truly physically and scientifically possible as that electro-magnetic sets of the same pitch should respond to one another.

Most of our actual knowledge of one another is derived through telepathy. The birds and all the lower orders of animals communicate thus with one another. Crows know when you carry a gun. Dogs feel it when you are afraid. Horses catch a sense of your worry. Woe to the one who tries to cover his inner dislike of children with soft and tender words! The repellent crying of the infant is generally an open rebuke.

Our communication with one another in the realm beyond this physical life will be telepathic. And when it is separated from the physical limitations, uncertainties and deceptions of this life, it will be an absolutely perfect mode of communication. Misrepresentations and deceptions will be impossible where knowledge is gained directly, intuitively, telepathically. That is the way in which God speaks to us, and we to Him. He hears not so much our words as our thoughts. "What you are speaks so loud, I cannot hear what you say."

This method of soul speaking to soul runs all through the Bible, as is clearly shown by the sane and safe presentation of the whole matter of telepathy by Dr. H. C. Stanton in his admirable book, *Telepathy of the Celestial World.* We heartily commend this work to all who are interested in the subject.

We have had sufficient evidence, in the numerous facts which have been presented, to show that the law of resonance like a scarlet thread runs through the whole of nature. All musical instruments, all material bodies, light and electricity, chemistry and machinery, the human body and all its senses, the mind and spirit of man, all conform to this law; they have their keynote. It is not too much, then, to conclude that God, the Author of nature and man, has His own keynote and that we can enter into communion with Him only as we are in tune with Him. We have seen that the moment things synchronize, response is both easy and instant. It is just as true, however, that when they are discordant, the response is difficult or wholly impossible.

It requires but a trifle so to throw two tuning forks out of unison that no response is possible between them. So of radio sets; or of sound waves and the organ of Corti; or of luminous waves and the rods and cones in the eye. A small thing suffices to destroy the resonance between human hearts. Harbouring a breath of suspicion, ill will or resentment makes them discordant. Many do not understand why their prayers are not answered. As well try to get radio stations with which we are not in tune, as to try to get heavenly

messages through discordant hearts. The first thing is, tune in; put away sin.

A tall glass jar or a large olive bottle may be used as a resonator. If a tuning fork be struck and then held over the mouth of the jar, perhaps no sound will be heard, but if water be poured into the jar slowly, a point will be reached where the column of air in the jar will vibrate in unison with the fork, and the jar rings out loudly. Continue pouring in water, and you throw it out of tune, and silence ensues.

In a similar manner radio receiving sets may have their notes changed, bringing them into tune with one station, only to be tuned out presently, to try another station.

We no less readily change our own personal key-notes, now determining to resonate with one person or thing, and then deciding to be in accord with another. One can will to harmonize with and enjoy his business, profession or family, or he can encourage and tolerate the reverse, and so feel accordingly. As well tolerate discords in the ear, and hope to hear clearly, or discords in the eye and expect to see, or discords in the body and think to enjoy good health, as to permit discords in the heart, and have a happy home or a successful and enjoyable business or professional career.

Watching a poor organ grinder's habits has conveyed to us important lessons. Instead of merely turning the crank of his hand organ in a mechanical way, as is generally done, and holding out his hat for a few cents, he keeps time with his tunes by the rhythmical motions of his body. He sways to and fro, rises

on his toes and swings back and forth, bowing and bending, all the time in unison with whatever tune he plays. How thoroughly he seems to enjoy his task, as if to say: "How beautiful is this music! What a fortunate man am I! Listen with me, and enjoy its charms!"

Fortunate, indeed, is he who is in tune with his tasks, who resonates with his environment and responds to his God. We are much like King Richard, who was secretly imprisoned on the Rhine. He had no liberty and little peace, but he had a persistent and faithful friend in Blondel who wandered up and down the land, singing before each prison the song which he and his master used to sing together in England. At last he was rewarded by hearing his song responded to, and sung in unison with him, from behind the grim walls of the prison in Lowenstein castle; and he knew that he had found his king.

God sings, over our imprisoned spirits, His note of exquisite harmony and sympathy, and when at last our dormant capacity is quickened into response, and we sing His song along with Him, our whole nature is vibrant with the harmony of heaven.

Frances Ridley Havergal reminds us that there was an æolian harp whose sweet strains could not be evoked by thrumming the harp with the hands; but when the sash was lifted and it was placed in the window and the winds of heaven blew upon it, all its sweetness was aroused.

Our soul is such an harp. Its beauty is not manifest when selfishness, vanity and discords are suffered to

play upon us and to control us. But when we open our window and let the breath of heaven, the πνευμα or Spirit of God, move us, all the harmonies and delights within make for health of body and vigour of mind, and reveal a golden cadence which is surprisingly attractive.

If a sea shell be held to the ear, it is often said, one can hear the sea roar. He actually hears, however, only the response which the column of air within the shell makes to the vibrations in the exterior world, as the resonating jar resounded response to the beats of the tuning fork. This truth is made apparent if the shell be held with one end to the ear, then the various keys on the piano be struck. When the note is sounded which is in accord with the vibratory rate of the column of air within the shell, the response from the shell is loud and clear, and you know its keynote. Bottles may be tested for their keynotes in the same way.

Every one has his own keynote. There is one dominant thing to which he more readily responds than to anything else. Any one of us may test his own note by observing what it is to which he most pleasingly responds. The radio set, the tuning forks or the sea shells no more clearly reveal their keynotes by that to which they respond than do we. Not what we say, profess or declare, but what we are, determines our keynote.

Many are able to discuss matters of finance, social affairs or problems of capital and labour by the hour, who would feel that a good word spoken for Jesus

Christ is out of place. That is because it is not their dominant note.

Heaven is not some region, realm or home, which one may enter, and by virtue of that fact be supremely safe and happy. It may be all of the above, but its chief characteristic is harmony. Love reigns supreme. Every one there delights in all others, and all delight in God, who is love and harmony.

Such a state of harmony may be experienced even on earth. Jesus could say: "Even the Son of man, who is in heaven." Yet He was on earth, amid its discords, injustice, selfishness and all manner of sin. These found nothing responsive in Him. He was not in tune with them, but was with the Father, with whom He was always in perfect harmony as when He ascended to be enthroned at His right hand. The hosts of saints who have preceded us are in heaven not because they are in a certain place but because they delight in the heavenly Father's will. One here on earth may meet with many perplexities, reverses and sorrows; he may amass no fortune, but if he delights in the Father's will, if he be "in tune with the Infinite," he has antedated heaven, for its chief element is within him.

The late Dr. Kittridge related that he spent one night in a Moravian hotel on the river Rhine. His room was next to that of the landlord's brother, who was very ill. He heard groaning and other sounds of suffering from the room. After a time, however, he slept, but later was awakened by sweet singing in the room. In the morning he inquired of the landlord as to his brother's condition. The reply was this: "He

has gone home." Not understanding, Doctor Kittridge said: "I thought I heard singing in that room." "And so you did, for it is the custom of us Moravians, when a Christian goes home, to gather around his bed and sing our most cheerful songs; for we want our songs down here to be in harmony with the songs up there."

When the song of our hearts is in unison with the songs up there, all is well with us.

PART III

RADIOACTIVITY

XIII

THE CHANGES IN SCIENCE

WITH the discovery of radium much of what was regarded as settled in science had to be rewritten. At that time, or shortly afterward, Professor R. K. Duncan in his *New Knowledge* said: " Where before them was solid, walkable ground to the older science, now there is nothing but shifting sand." He mentions the names of the following distinguished scientists, who are all " the pride of their universities," Lord Kelvin, Becquerel, the Curies, Rutherford, Ramsay, Crookes, Lodge, Soddy and others, and adds: " Their names and work will long hold out ' against wreckful siege of battering days.' Their statements of fact may, emphatically, be believed."

That was twenty-two years ago. They are still great names in science, yet one does not dare to quote the statements which they then made, until these are confirmed by themselves or by other scientists writing at the present time. At that time it was confidently asserted that the hydrogen atom contains 770 electrons; that, the atomic weight of hydrogen being 1, the number of electrons in any atom could be obtained by multiplying its atomic weight by 770. By that method the uranium atom was found to contain about

181,000 electrons, and the radium atom 173,000. Now, however, the hydrogen atom is known to have one electron, the radium 88 and the uranium atom 92, exterior to the electrons in the nucleus.

Soddy said: "For the first time we have passed within the atom. By so doing we have left behind the old sciences as though they no longer existed. Science has now to begin all over again, right at the alphabet."

It is interesting to note that these leaders in scientific discovery do not hesitate to acknowledge that their previous statements have been superseded by more recent discoveries. It is nothing derogatory to science that what is stated as facts today, may be modified tomorrow. This is true, however, only regarding the interpretation of certain discovered facts. Facts never change, but the inferences from them are changeable. For example, it can never be doubted that radium manifests certain forms of energy which until within recent years were wholly unknown; that it will discharge an electroscope; that it will kill certain disease germs and destroy living cells in the human body and accomplish a multitude of other feats. It is the knowledge of the *how* and the *why* and other like processes which fluctuates, and yet ever forges ahead, because of solid foundational principles on which to stand.

These kaleidoscopic changes in science, though the basic facts remain, ought to encourage the faith of devout Christians in things religious. All down the ages there have been divergent views and consequent

controversies regarding degrees of Biblical inspiration, the person and work of Christ, the origin of sin, the being and nature of God and many other doctrines. There have always been advance thinkers, opposed by the cautious, the doubtful and the believing; schools of authority and the new schools of individualism have been contesting each step of the way and often waging a war which is anything but brotherly.

Yet, with all the changes, certain foundational facts will always remain, as in matters of science. The Bible, read and followed, has always worked, and continues to work, great changes for good among men; personal peace, joy and victory flow from it as flow waters from a subterranean river. Christ is, and has been for nearly 2,000 years, a transforming power in the lives of those who trust Him. Prayer still accomplishes results which are a marvel, and to none so great as to those who experience it. Transforming miracles are, and ever have been, wrought in the lives of those who by faith test the good news in the Gospel. These and a thousand other facts remain, and will always be, reliable, however many theories and deductions may rise and fall as the years pass along.

Men may debate over the theory of relativity, but gravitation will always exert its pull on all objects; the quantum theory of energy will fluctuate, but energy in numerous ways will continue to bless and help those who conform to its laws; atoms will always cohere to form molecules, and molecules to make material bodies, however many theories may change as to atomic construction and disintegration. No one would think

of discarding scientific discoveries, or of belittling scientific facts, because of modifications made in the deductions from those facts from time to time.

When Soddy said that " Science has now to begin all over again, right at the alphabet," he did not mean that we have to go back to the days prior to Newton and Kepler and Galileo, or even to Morse and Franklin and Von Humboldt. He did not mean that the facts discovered by such men were invalidated, but merely that the theories and deductions which they and others made from those facts, these alone have been superseded. They did not go far enough. They stopped at the door of the atom, or near to it. Now that we have gone within it, a new universe, so to say, is open to us, and many are the discoveries.

In Christian things we do not have to go back and begin all over again, right at the alphabet. We stand on the solid foundation on which the Apostles, early Christians and our forefathers stood, that Christ and His grace draw men and transform them from sin and degradation into noble and useful lives and that Christ does things now, as always, for those who trust Him. Let theories wax and wane and controversies rage; the foundation of God stands secure. He knows His own, and they know Him; they have fellowship, a correspondence or oneness of life, thought and feeling in things spiritual and eternal.

It is only science " falsely so called " which leads to skepticism and uncertainties, not real science, that " knowledge which is gained and verified by exact observation and correct thinking and methodically form-

ulated and arranged in a rational system." Such knowledge always leads to admiration and reverence for the Creator, when it is seen and dwelt on. Such science sees that nature is " the way God is working," and it always leads to Him, when it is reverently studied. No wonder that men like Kelvin, the Herschels, Faraday, Maxwell, Newton, Pasteur and hosts of other students of nature adored and worshipped God. The cultured Joseph Addison expresses it:

> The spacious firmament on high,
> With all the blue ethereal sky,
> And spangled heavens, a shining frame,
> Their great Original proclaim.

It is only as men leave foundation facts in the study of nature for personal theories, that they are in danger of permitting human conceit to supplant the innate consciousness of God in their thoughts, and so of ending in darkness regarding Him.

The study of radium and its mysteries, as all other branches of science, if done with an open and reverent mind, cannot but be a way leading up to God; and all along the way one is wont to exclaim: " How manifold are thy works! In wisdom hast thou made them all! "

XIV

RADIUM AND ITS MYSTERIES

CONCERNING the substance radium which has proven to be the key that has unlocked many hitherto closed doors, there are several questions which one naturally desires to have answered. What radium is; where it is found; what it does or is good for; what it is like; what it costs; how it is explained.

These questions cover a very wide field in physics, and to present them would require a large volume; moreover, by the time it was written and read, it would need to be revised. For new things are ever coming into view regarding radium's ancestors, descendants and other relatives in the chemical world. It is said to be about as rare in nature as gold is in the sea water.

It is an element; not like water for instance, which is a compound of hydrogen and oxygen, and can be decomposed into those two gases. Like gold or oxygen, radium cannot by any chemical processes be separated into component parts. No amount of heat, however great—and the electric furnace can develop as high as 12,000 or 14,000 degrees Fahrenheit, hotter than the sun—nor any extreme cold, no electrical or chemical processes, can change radium in the slightest degree. It is the most wonderful element which has

ever been discovered, and has had more to do with letting us into the secrets of nature than perhaps all other factors combined.

Radium's appearance on the stage of human knowledge has relegated many books of science to the background and sent many theories into the scrapheap. It tells us about the nature of things on earth, what is being done in the stars and what the end will be of things physical.

It is found in largest quantities in pitchblende ore, a rare mineral used in the manufacture of expensive glass. A ton of pitchblende contains about one-fifth of a gram of radium, and not more than four-fifths of that can be isolated by a long chemical process.

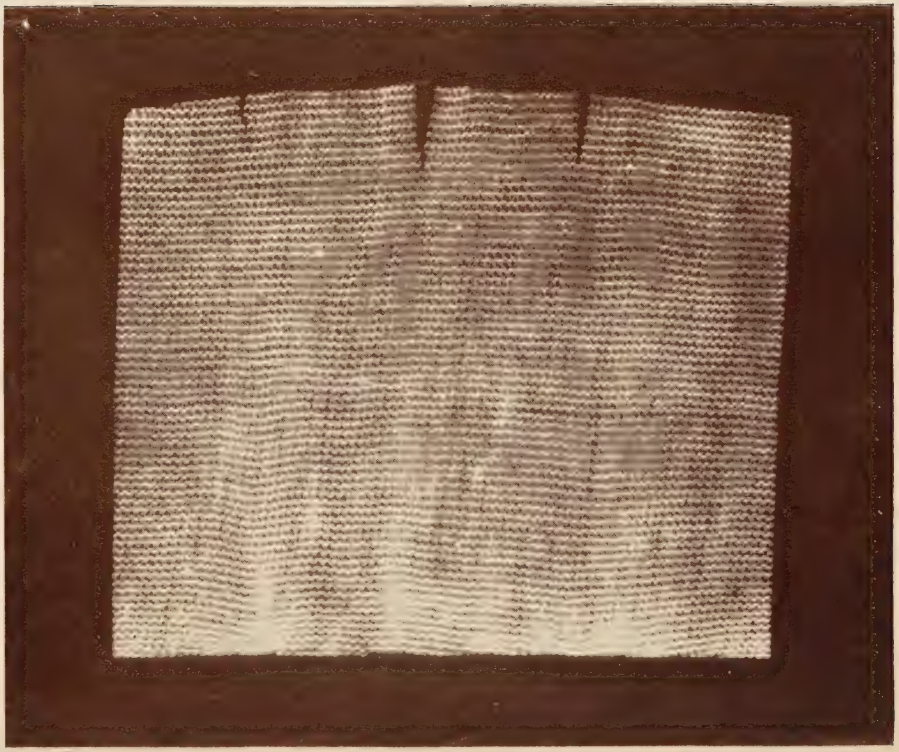
Our respect for Madame Curie is increased when we recount briefly, and in part, the processes by which she isolated radium. The ore is crushed, roasted with carbonate of soda and treated with hot water and diluted sulphuric acid, and a residue obtained which contains lead, calcium, silica, aluminum, oxide of iron and traces of copper, bismuth, zinc, cobalt, manganese, nickel, vanadium, antimony, thallium, rare earths, niobium, tantalum, arsenic and barium. This is treated with strong boiling caustic soda, to get rid of the sulphuric acid. Then, with hydrochloric acid, when certain elements are removed; then with ammonia, others being removed; then with strong boiling carbonate of soda; washed with water; dissolved in hydrochloric acid and filtered and precipitated with sulphuric acid. Other elements are thus removed. After this the solution is treated with sulphuretted

hydrogen, is filtered, oxidized with chlorine and precipitated with pure ammonia, then precipitated with carbonate of soda. Finally a residue is obtained which is sixty times as radioactive as uranium.

Then begins fractional crystallization, in which the solution is crystallized, the crystals removed and tested. A platinum wire is dipped into the salts and then into the blue non-luminous flame of a bunsen gas burner. The characteristic green colour of barium is seen in the flame, but after further crystallizations, and a close examination by means of a prism, the green flame fades, and a red one is seen. And finally, after thirty or so steps in crystallization, the merest pinch of a substance is obtained in which no green barium rays can be seen. So a radium chloride has been obtained which is a million and one-half times as powerful in radioactivity as the parent uranium.

At the present time the largest production of radium is in the Belgian Congo, where a rich pitchblende ore has been found which yields, it is said, a gram of radium for about every ten tons of the ore. Until that discovery, the United States Bureau of Mines, in collaboration with the National Radium Institute, produced the largest amount of radium in the world—from the Colorado carnotite ore.

In his address at Washington, May, 1921, at the time of the presentation of a gram of radium by the women of America to Madame Curie, Dr. Millikan stated that it took 500 tons of carnotite and as many tons of chemicals to get that one gram of radium. Now, however, with the processes of extraction less



A Photograph Taken Without Light

A Welsbach mantle in contact with a photograph plate, and left for a week in a light-proof box, clearly photographs itself, as may be seen in the above cut. (*See page 181.*)

elaborate, and with a larger content of radium in the ore, the price should be somewhat lowered; but it will never be so cheap as gold or diamonds.

One gram is not far from one-thirtieth of an ounce. The total output of pure radium which has been extracted thus far amounts to only 150 grams, and it is estimated that not more than 500 grams are available in the earth's crust. Yet, according to Professor Joly, about one one-thousandth of a milligram of radium per ton is the average content of the rocks of the earth; 20,000 tons of it are in the seas, and more than a million tons are in the sediments which have been deposited over the floor of the ocean.

What radium does, or is good for, can best be listed under six heads, as follows: It is luminous, chemical, electrical, mechanical, thermal, physiological.

Luminous. Radium gives out light for ages. One can easily demonstrate its light-producing power by the following experiment. A small piece of pitchblende, or carnotite ore, laid on an opaque photographic plate-holder inside of which is a photgoraphic plate, will photograph itself perfectly in a short time. How many ages the pitchblende has existed and been pouring out light, no one can tell. Other rocks which are radioactive will do the same thing, though less quickly.

The thorium in the solution with which Welsbach mantles have been saturated radiates light also. Get such a mantle before it has been used, cut it open and lay it flat in contact with the film side of a photographic plate, with a glass laid on it to keep it flat. Put it into a light-proof box, in a dark room, for a

week, and then develop it; the mantle will have perfectly photographed itself.

Chemical. Radium changes, in some degree, all that which it touches, though itself is unchanged. The glass tube in which it is contained soon changes from a clear transparency to a violet colour. The radioactive element, thorium, which is in solutions with which gas mantles have been saturated will produce the same changes in glass; hence, one can tell which globes on street lamps have been used for several months by the violet colour of the globes. The impact of the radioactive particles, bombarding the molecules of the glass, have changed their colour.

Radium will also decompose water into its elementary constituents—oxygen and hydrogen.

Electrical. Radium will discharge an electroscope instantly—a million times faster than uranium. A piece of pitchblende, or carnotite, held near such a charged jar, will cause the leaves to collapse at once. In fact, it creates an electric atmosphere about it; for it radiates electricity itself, as we shall see later.

Mechanical. Radium's mechanical effects are beyond comprehension. The energy set free by it is millions of times greater than any known chemical change, in an equal quantity of material. One has said that every breath which we draw has within it sufficient energy to drive the workshops of the world. Some day man will tap this energy. In a small measure this has been revealed in the atomic energy displayed in radium and other radioactive substances.

Radium gives off negative electricity. To create

one gram of such electricity would require one trillion horse-power, working 680,000 years. According to the calculations of F. F. D'Albe: "If two grams of pure electricity, or electrons, were put one centimetre apart, they would repel each other with a force equal to 320 septillion tons," which is 100,000,000 times the gravitative pull of the sun on the earth, four quintillion tons. That is a force which—all other forces being nullified—would lift, pull or push aside 100,000,000 worlds such as this.

Of course, it is utterly impossible to think of a gram of pure electrons ever being isolated from all other forces except their own, or of even one single electron so controlled. But that calculation suffices to show with what tremendous forces we are surrounded. And yet, because they are perfectly counterbalanced by other equally powerful forces, we live calmly and serenely amid them, utterly oblivious to the fact that were the equilibrium between them to cease for a single moment, we and all others would be instantly shattered into destruction.

It is estimated that one ounce of radium contains sufficient energy, could it be controlled, to hurl a building weighing 10,000 tons a mile high. And, Professor Millikan says, "If all the radium at present in the world, now isolated, were set to work, although it is 300,000 times as potent as coal per gram in giving off energy, it would not suffice to keep the corner popcorn man's outfit going. It does not exist in sufficient quantity."

Thermal. The thermal or heat producing effects of radium are no less wonderful than its luminous, chem-

ical, electrical and mechanical effects. "It maintains itself steadily," says Strutt, "at a temperature of about three degrees above its surroundings." The heat of the sun may be due to the presence of radium. It would need be only slightly more of a percentage, many say even less, than is contained in good pitchblende, to account for all its heat and energy. Moreover, according to Professor Joly in his *Radioactivity and Geology,* the internal heat of the earth and of the earth's crust is due to radium, which constitutes not less than two parts in a trillion. And instead of the earth cooling off, as many have long maintained that it is doing, and being destined at some time to be a dead, cold world like the moon, just the contrary will be the case. It is growing hotter because of its own internal stores of energy resident within the elementary atoms of which it is composed. The conclusion is, that the earth is ultimately to pass through some such holocaust as that which was prophesied by Peter, in his second epistle, the third chapter, as other heavenly bodies have done and are still doing. Professor Joly concludes: "That the temperature of the earth is rising, instead of falling, seems to be the only logical view open to us, on our present knowledge. And if the conditions are such as to involve the accumulation of great stores of atomic energy, who knows but the sudden flaming up of a star in the remote heavens may not mark the inevitable catastrophe and define, in some distant planet, the end of a great cycle of organic evolution and, perchance, herald yet another 'In the beginning'?"

Commenting on this statement, Dr. Millikan says: "Then this earth, instead of cooling off, is actually now heating up; so that in a hundred million years the temperature of the core will have risen through 1,800 degrees centigrade. That is a temperature which will melt almost all our ordinary substances. What does this mean? It means that the life history of our planet is perhaps not at all what we have hitherto thought it was. It means that a planet that seems so dead as this our earth seems to be, may, a few eons hence, be a luminous body, and that it may go through periods of expansion when it radiates enormously, and then of contraction when it becomes like our present earth."

These are deductions from certain facts by celebrated scientists, and whether we credit all their conclusions or not, the fact remains that radium is giving out great quantities of heat, and that continuously.

Physiological. Radium has become widely known, also, and has aroused discussion and awakened hopes, because of its physiological effects. From the first, it was tested as to its effects on insects and animals. Some animals, like rats, were killed by exposure to its rays. The larvæ of certain moths, exposed, had their development retarded, so that they remained three times as long in the larval stage as is normally the case. If the same effects should hold true with human beings, then a girl at 18, by occasionally looking at it, would continue her youth and beauty until in the seventies. But if overdoses of attention were given to it, the eyelashes and eyebrows would be burned off,

the hair would fall, and blindness, paralysis and death would follow.

Hospitals and radium institutes are using the radium treatment for certain diseases, particularly those of a cancerous nature. The author has heard Dr. Howard A. Kelly of Johns Hopkins University, Baltimore, say that he has unquestionably cured people suffering from cancer; but he qualified this announcement with the statement that when that disease, like any other, has advanced beyond a certain stage, there is humanly speaking no cure possible.

The combined report of the United States Bureau of Mines and of the National Radium Institute states that the gamma rays of radium have a remarkable virtue in the treatment of cancer and other malignant growths. "The bureau knows of no individual or hospital that has had the privilege of working with so much as half a gram of radium, that does not report cures in increasing number, or that is not able to treat even advanced cases with increasing assurance of success, as a knowledge of technique is developed."

For the best results, 500 milligrams or more are necessary, and many working with but few milligrams, and not pure radium at that, have failed to report good results. Purity and quantity are highly essential.

The present cost of radium is about $100,000 per gram. That this is somewhat less than the price in former years is due to the extraction of radium from carnotite ore in Colorado by the National Radium Institute. The price depends much upon its purity; there are very few perfectly pure specimens in exis-

tence. The present cost price would be about $3,000,000 per ounce and $36,000,000 a pound.

There are many other things, perhaps all the elements, which are undergoing the same process of disintegration of the atom, only in a less degree, as we see in radium. Soddy states: "The period of past existence of the atom can have nothing to do with its disintegration. The latter is not the culmination of a gradual process of evolutionary change which is at work in the atom all the time. Chemistry on the whole is also against any gradual evolution of the elements in this sense. Each atom carries within itself some sort of independent clock which explodes it at the appointed time."

This disintegration of the atoms is an unwinding of the elements; the very opposite of evolution, it is a devolution. In such spiral nebulæ as are known to be of a gaseous nature there seems to be a winding up process, a coiling up, as of a spring, into solid bodies constituting the stars. And in the planets, like the earth, there is an uncoiling of energy, known as radioactivity. Our sun, and many of the stars, exhibit this unwinding of energy, the atoms disintegrating and releasing radiant energy known to us as light. The winding up process is manifest in other of the heavenly bodies also, the heavier atoms forming and storing up energy, while the whole mass is shrinking together, contracting—only in later ages to begin again the unwinding process, as seen in radioactivity. In other words, worlds are being born, growing to maturity and then dying and in their death are becoming the pos-

sible abode of other and intelligent life, which they foster, sustain and bless, as our earth has blessed the human race.

The worlds are thus a picture of our own lives, a birth, growth, an accumulation of energy and later a running down, a decay, a disintegration which is intended to impart blessing to our environment on every hand.

This is also a type of the greatest of all births, growth and death—a career because of which, in the disintegration, there was released such energy, such healing virtue, such mighty and transforming power, that even the dead are quickened by it. Possessing a new life and power, they themselves in turn become lights of the world, ambassadors for Christ, priests before God and saviours of their fellow-men.

The uncoiling of the elements, the disintegration of atoms, which releases vast stores of energy, seems to be characteristic of all things terrestrial. Freshly fallen rain and snow are radioactive; so are the air of caves and cellars, well water, all kinds of rocks, clay, refuse from furnaces. These and numerous other things reveal the processes which are going on within their atoms by their radioactivity.

Radium reveals to us the fact that the atoms of matter, beginning with uranium, the heaviest, and going down the scale of atomic weights, are being changed into simpler forms; that is, lighter atoms with new names. The genealogy of radium, as given in an attractive way by Dr. Slosson in his *Creative Chemistry,* is an interesting illustration of the devolution of atoms.

"Putting the chemical genealogy of radium into biblical language, we might say Uranium lived 5,000,000,000 years and begot Uranium X1, which lived 24.6 days and begot Uranium X2, which lived sixty-nine seconds and begot Uranium 2, which lived 2,000,000 years and begot Ionium, which lived 200,000 years and begot Radium, which lived 1,850 years and begot Niton, which lived 3.85 days and begot Radium A, which lived three minutes and begot Radium B, which lived 26.8 minutes and begot Radium C, which lived 19.5 minutes and begot Radium D, which lived twelve years and begot Radium E, which lived five days and begot Polonium, which lived 136 days and begot Lead. The figures I have given are the times when half the parent substance has gone over into the next generation. It will be seen that the chemist is even more liberal in his allowance of longevity than was Moses with the patriarchs. It appears from the above that half of the radium in any given specimen will be transformed in about 2,000 years. Half of what is left will disappear in the next 2,000 years, half of that in the next 2,000, and so on. The reader can figure out for himself when it will all be gone. He will then have the answer to the old Eleatic conundrum of when Achilles will overtake the tortoise."

It is interesting to note that, though the processes occurring in radium explain to us many of those occurring in the sun and stars and in numerous electrical phenomena hitherto not understood, at the same time many of those electrical manifestations, as those in X-ray and Crookes tubes, and so on, make clear to us what is occurring within the atoms of radium and other atoms. Hence we will turn our attention to some of those experiments.

XV

SIGNIFICANT EXPERIMENTS

NOTHING stands still. Bodies have three motions: The translatory or free path, which is longitudinal; the rotary, as that of a wheel; and the vibratory, back and forth like a tuning fork, or the transverse.

We may state as a general principle that all hot bodies vibrate. We can almost see the vibrations of a flame and can see the air vibrate about a hot fire as it surges back and forth. Furthermore, all bodies are hot. The amount of heat which a body possesses is determined by the number of degrees it is above absolute zero. Ice has so much heat that if it be brought into contact with liquid air, the latter will immediately boil, and its vapour could be employed to put motors into operation.

Ice is as truly a source of heat as a glowing coal, and for the same reason. The difference between them is in the degrees of heat which they radiate. Ice stands at 32° Fahrenheit, and absolute zero is -461°, so that ice possesses 493 degrees of heat.

When heat is added to bodies, it increases the rapidity of their atomic vibration; in metals we often do this until they begin to glow with a red colour, and as the heat is increased their atoms vibrate through an

amplitude wide enough to produce in our eyes the sensation of white light.

Many of the vibrations of gases, air waves and atoms have been counted, and their wave lengths determined, as will be seen by reference to the Chart of Waves.

It is also known that when bodies have vibrations which are in unison, they can be made to respond to one another. This we saw in considering the Law of Resonance in Ether Waves. Bodies will absorb those vibrations with which they are in sympathy. What is known as sympathetic vibration takes place when a body sends its waves upon another whose vibratory period is of the same rate or which is attuned to the same pitch. Then the amplitude of the vibrations of the second body is increased; if it be in sound, it is heard resonating with the first; if it be in light, it reveals its response in light waves.

Poincaré speaks of atoms as resonators. They may also be considered as small molecular tuning forks, capable like ordinary ones of vibrating response to certain notes but not to others. When they are struck by ether vibrations, they reveal their keynote by vibrating in unison with certain vibrations and by not accepting impressions from others.

When the atoms of a body take up the energy falling upon them in waves of ether, their vibrations are said to be forced; absorption occurs, and the body is opaque just in proportion to the energy absorbed. If the atoms of the body do not synchronize with vibrations of the ether, there is dis-

cord; the waves pass through it, and the body is transparent. Absorption is accord, and is synonymous with opacity.

This statement explains fluorescence and phosphorescence generated by light waves. When such waves fall upon a body and are absorbed, producing a vibration of the atoms in longer periods than of the incident waves, we have fluorescence. This ceases as soon as the waves cease to impinge upon the body. If the object continues to glow for some time after the light has been removed, we have phosphorescence. In both fluorescence and phosphorescence there is an altering of the very short waves of ultra-violet light, which are invisible, and a transforming of them into waves of longer length so that they become visible to our eyes. In electrical parlance, such substances that fluoresce, or phosphoresce, might be termed step-down transformers or, more accurately, frequency changers for ether waves.

In a piano a wire whose vibratory rate is 435 times a second will absorb the waves and respond to a wire vibrating 3,480 times a second, though it is three octaves lower than that wire. It is then a step-down wave transformer.

Numerous substances are similar step-down ether wave transformers. Here is a piece of cardboard which has had large letters traced on it by powdered calcium sulphide, mixed with gum tragacanth in a paste form. When the cardboard is held in the sunlight for a moment it is seen to glow in the darkness. If the cardboard be placed on the back of a photo-

A Photograph without Camera or Lens

A copy of a wood cut, taken from a book without camera or lens, by the phosphorescent rays from a card painted with calcium sulphide and then held in the light of a lamp for a moment. Exposure behind the wood cut one hour.

(*See page 192.*)

graph and a photographic plate on the front of the photograph, and all three be put into a book, the light from the cardboard will pass through the photograph, X-ray like, and blacken the photographic plate, and a negative can be obtained. Photographs and cuts in books may be copied thus without a camera.

In the darkness, if such a cardboard be exposed to the light of a burning magnesium ribbon, it will phosphoresce brilliantly. The magnesium ribbon is rich in ultra-violet vibrations. Though its light is very brilliant to the eyes, it is a light which covers several octaves, and the greater portion is of the ultra-violet rate.

The cardboard exposed to the sun for two seconds will phosphoresce, and will continue to glow for a long time, somewhat as a bell will continue vibrating after the hammer has ceased striking it. After three days a photograph can be made from the cardboard by an exposure of two hours; after fifteen days, by an exposure of twelve hours; after six months, forty days; after eighteen months there will be a faint image after an exposure of sixty days.

Iron heated to incandescence is rich in ultra-violet light. Here are the two terminal wires from an induction coil, each having a small iron bolt attached to it, and they are passed through a block of wood so that the bolts are about one-quarter of an inch apart. There is an extra condenser on the secondary of the coil, and when the current is turned on a snappy condenser spark is heard.

Here are a dozen or more stones, secured from a

mineralogist, all of which will phosphoresce under the impact of ultra-violet light waves. I hold the spark from the iron electrodes over these stones, and they light up brilliantly, many of them with a different colour than they show to the naked eye. One, a piece of willimite, glows with a brilliant greenish colour. A piece of zincite turns red; calc spar an orange. Others phosphoresce a yellow or a bluish cast, and a deep violet—all the colours and shades of the spectrum.

A whole octave of vibrations from the iron electrode lamp is thrown upon each stone, which selects out of that octave such vibrations as it is in tune with, and absorbs the energy; the amplitude of its atomic vibrations is increased, and we see its colour. And thus we learn the keynote of each one of the many minerals, and know the atomic rate of its vibrations. For example, the dark brown stone, which turns red under the searching impact of the ultra-violet rays, has the secrets of its inner nature laid bare before our eyes. We read its hidden conduct. The combination of its atoms cause it to work at a furious pace. They vibrate 434 trillion times in a single second. To count its work, in that one second, would take any one of us 215 million years without stopping day or night; and it would take all the people in the United States nearly two years to count its railway trips of one brief second. And the stone with the violet colour runs express trains which make twice as many trips in a second.

The stone with the red colour sings with a bass note among the colours of the stones; the quartz turning

violet is a high soprano; and the willimite, turning green, is a mezzo-soprano in the colour octave. Its molecules vibrate 520 trillion times a second.

There are "sermons in stone," certainly; they are delicate musical instruments—parts of nature's piano, to voice their music to all who have ears to hear.

Here is a Crookes' tube, a glass bulb, exhausted to about a millionth of an atmosphere. Inside is the small figure of a man. He has been painted over with different minerals, like fluorspar, kunzite, uranite and the like. His entire appearance to the naked eye is a brownish red. When, however, I turn on the current from the induction coil, the cathode rays from the negative terminal, a whole octave of vibrations fall upon the little man, and now he lights up with all the prismatic colours; his boots red, socks white, trousers green, vest orange, coat yellow, hat blue, collar violet, and so on. Each mineral responds to and absorbs the waves with which it is in tune, and so reveals its true colour.

A piece of zincite, suspended in such a Crookes' tube, has the cathode rays turned upon it, and it glows like a coal of fire.

Here are a number of Geisler tubes, several of which contain an inner tube. Some contain nitrogen gas, others carbonic acid gas, some petroleum and others various liquids and gases. When the octave of electric waves is passed through them they light brilliantly with numerous colours, revealing the fact that gases and liquids also have their keynote to which they readily respond. Like men and women, they cannot keep

silent when their keynote sounds, but respond on the instant, and always with something beautiful.

When the current is sent through a very highly exhausted vacuum tube the glass of the tube fluoresces with a pale green, showing that soda was used in its construction. The cathode rays fall upon a metal plate and are deflected to the side of the tube, creating waves on the outside of the tube. I take a cardboard which has been painted over with platino-cyanide of barium and hold it near the tube, and the card immediately lights up with a bluish colour. When I thrust my hand in between the tube and the cardboard the shadows of the bones of the hand are seen outlined on the cardboard. Here are the X-rays, and these are in tune with the vibratory rate of the molecules of the platino-cyanide of barium. The response of such substances to the X-rays gives us the only way in which we can see them, for they are several octaves above the range of vision, as will be seen by reference to the Chart of Waves.

Here is a Crookes' sun radiometer. It has aluminum vanes which are mounted on a light frame work pivoted on a needle point enclosed in a highly exhausted bulb. Each vane is blackened on one side and polished on the other. When sunlight falls on the vanes the rays are absorbed by the black and are reflected from the polished surfaces. Absorption by the blackened surfaces means rise of temperature. This heats the residue of air in the bulb, and the heated gas molecules, striking the hot blackened surfaces, rebound away from them; since action and re-

action are equal and opposite, a pressure is exerted on the blackened sides of the vanes, and this drives them around at high speed. The polished surfaces, not heated so much, have less pressure on them, and the vanes revolve as if they were repelled by the light.

The point which we wish to notice is that a whole octave of vibrations from the sun fall upon the blackened sides of the vanes, and the blackened material, being in tune with the light waves, absorbs them.

The sunlight exerts a true pressure on a surface on which it is incident, and this pressure is twice as great on a reflecting surface as on an absorbing surface. But in this case the blackened vanes, absorbing the energy of the ether waves with which they synchronize, creates a heat and, consequently, a rebound of the molecules of the air and a return impact from them which more than counterbalances the light pressure on the polished surfaces of the vanes.

In this connection it is worth noting that a comet, as it approaches the sun, develops a tail which is always away from the sun, and may be of any length up to a 100,000,000 miles. The pressure of the sunlight drives away the lighter tail, no matter what may be the direction of the comet's motion. When going from the sun the tail now precedes the comet's head, as the smoke from an engine is blown ahead of the train.

Here is another larger vacuum bulb, containing a bunch of metal flowers, silver coloured, suspended

from the bottom on a wire standard. Above these is a mill-wheel arrangement, with the vanes shaped like a propellor of an engine on steam boats. When the cathode rays are sent into this tube the flowers all glow with various colours, revealing the fact that they were painted with different phosphorescent substances, each one of which has its own vibratory rate and absorbs the energy from the cathode rays with which it is in tune.

At the same time the vanes at the top begin to revolve with great speed. Something is propelling them. That something consists of the electrons in the cathode rays. They bombard the vanes and so propel them rapidly. This is shown also in another tube, having tiny rails on which is a small wheel; the wheel is driven before the electrons, or beta particles, away from the cathode, or negative, end of the tube.

Here is another cathode ray tube which has a maltese cross suspended on a hinge at the end of the tube. When the rays fall upon this it casts a shadow on the end of the tube. If a magnet be held near the tube, the rays will be deflected—pushed out of the tube, if the negative pole of the magnet is presented, or drawn out of it, if the positive pole is held near the tube. The cathode rays, then, are material particles, which at the same time are negative electricity, consisting of negatively charged particles, or electrons.

They move at great speed, from 10,000 to 60,000 miles a second. They travel twenty-one miles while the swiftest projectile from high powered guns goes one foot. The speed of some of these tiny projectiles,

particularly those shot from nature's weapon, radium, travel nine-tenths of the speed of light, or more than 160,000 miles a second. That would make the speed of Big Bertha's projectiles seem like a snail's pace. Their range was said to have been seventy miles; if we allow 5,280 feet, or a mile, a second as the muzzle velocity—which no gun can ever make—it took the projectile seventy seconds to reach the target. We will give our tortoise, the shell, thirty-five miles handicap; he starts on his race when our little Achilles, the beta bullet, begins his own race. The little one passes the slow lumbering one, and goes on his journey around the earth, and comes up with the tortoise and passes him, and repeats this again and again; 200 times he goes around the earth, and arrives at the target at Paris in time to warn all its inhabitants and those of all France by radio of what is coming, before the tortoise projectile arrives. Or, if he does not stop to warn the people, he can make twenty more trips around the world, and still win the race.

The impact of these β particles against the globe through which they pass produces the X-rays. Their waves, on being absorbed, cause phosphorescence.

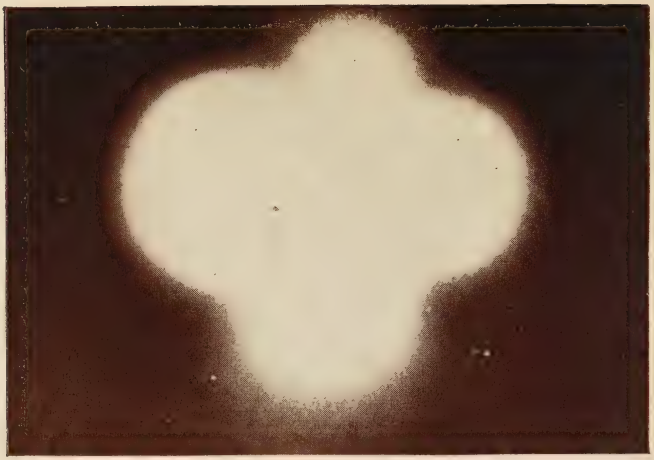
The phenomena which we saw occurring in the various vacuum tubes are the same which occur in radium. It radiates light which produces fluorescence and phosphorescence. A diamond held near to it in a dark room phosphoresces with a bluish light. This is a test for the genuineness of diamonds.

Zinc sulphide into which a tiny portion of radium has been mixed will glow perpetually in the darkness.

This is put on the dials of watches and clocks to make them luminous in the darkness. The atomic vibration of the sulphide of zinc is in accord with the vibrations caused by the radium. Hence, sulphide of zinc is a step-down transformer for the radium light, and though the vibrations are far beyond the range of vision, the synchronizing response of the sulphide of zinc slows them down to the visual octave of vibrations.

The way zinc sulphide resonates response to the radium light is seen in the spinthariscope. A small metal point is dipped into some radium, and a microscopic portion of the latter adheres to the metal. This is mounted within a small metal tube, under a lense, about one twenty-fifth of an inch from a small zinc sulphide screen. When looked at through the lense in a dark room scintillations, like falling stars, are seen. The alpha particles which are projected from the radium with great speed, from 10,000 to 20,000 miles a second, fall upon the sulphide of zinc, and each impact of the α particles, like so many bullets, breaks off a portion of the sulphide of zinc crystals, somewhat as flint, striking steel, breaks off particles of steel which fly away red hot and are seen as sparks. So the bombardment of the screen produces flashes of light, as if they were hundreds of stars. The appearance is much like the Japanese sparklets, without the central part which glows.

Here, doubtless, is another instance of tuning. The impact of the α particles, producing a cleavage of the crystals of zinc sulphide, causes vibrations which are seen as light waves. These have their definite vibra-



UNUSUAL PHOTOGRAPHS

Top. Radium light photographs through iron, page 201.
Bottom. The rock, pitchblende, laid on a light-proof plate holder photographs itself even through the opaque cover. (*See page 202.*)

tory rate, their keynote, and must be in tune with the force which produced them. It is motion turned into music, speed into light.

Concerning the speed of these α particles, Sir Ernest Rutherford says: " If it were possible to give an equal velocity to a cannon ball, the heat generated by the impact on the target would be many thousands of times more than sufficient to melt the cannon ball and dissipate it into vapour."

The β particles when projected from radium move eight times more rapidly than these α particles, and with both the momentum and impact accordingly increased, the cannon ball, and also the target, if it were the steel hull of a battleship, would be instantly converted by the heat into vapour, and both would vanish entirely. No natural body in the universe thus far discovered moves so rapidly as do these β particles; they are our Achilles racers—they are electricity.

Radium. Here is a small glass tube, about one and a half inches long, which contains a few milligrams of radium. It is far from pure, probably its radioactivity is not more than 10,000 or 20,000. That is, it is 20,000 times as radioactive as uranium, the unit of radioactivity. If it were absolutely pure, it would be rated at 1,500,000, and that would mean at least seventy-five times as energetic in its radioactivity as this small specimen.

Yet, small and comparatively weak though this radium is, it produces very wonderful results. Its light will pass through the opaque cover of a photographic plate holder and blacken the plate inside, and

do it quickly. I laid it across two iron washers, on the outside of the plate holder, and its radiations, or gamma rays, not only passed through the holes in the washers, but through the iron also, and blackened the plate as if no metal had been present.

The spinthariscope, which I mentioned as having only a microscopic bit of radium on its metal point, was laid on a wrench, on the outside of the opaque plate holder, and its rays in a few minutes found reaction in the photographic plate, and a fine radiograph of the wrench was obtained.

The pitchblende photographs itself, though it is only one-millionth as radioactive as radium, and contains only one part of radium in 300,000,000 or 400,000,000 parts of the material. It also made radiographs of the wrench as clear and definite as the radium, but a longer exposure was necessary.

I spoke of the chemical on the sensitized photographic plate as reacting to the gamma rays of the radium. This means that the chemical atoms on the plate had a rate of vibration which was in accord with the vibratory rate of the gamma rays projected from the radium. Those gamma rays occupy the highest octave in the scale of vibrations, as will be seen by referring to the Chart of Waves.

Were it not for this law of resonance which runs through all nature, there could be no such thing as a photographic process. The chemicals on the photographic plate, like so many piano wires, were in tune with the tremendously high tones of the gamma rays.

A very striking illustration of this law of the musical

construction of nature is seen in the next experiment. Here is an induction coil, such as is used on automobiles, only this is a very large one, giving a spark between the one-inch brass balls of the secondary terminals of the coil, of ten inches. This means a very high voltage, 40,000 or 50,000, but the amperage, or amount of current, is very small.

By attaching another coil, known as a Tesla coil, and a condenser, to the terminals of the induction coil, the pressure, or voltage, is stepped up from 40,000 to probably about 200,000 volts, while the amperage is practically nil. This is a high frequency current, vibrating several hundred million times a second. The sparks fly from the brass ball terminal of this coil in a large brush, or fan, shape and extend a foot or so from the ball. The noise of the machine is very impressive, like the sparks from friction machines. The actual output of energy from such a machine, however, is very small.

It is worthy of note, in passing, that in currents of induction coils and other transformers, as we step-up the voltage, we do so at the expense of the energy output, or amperage. The relation of voltage to amperage is well illustrated by heat. The flame of a match, and the flames of a bonfire of several loads of wood of the same material as the match, will register the same temperature if you thrust a thermometer into the two flames. The degrees of temperature represent the tension, or voltage, in the electric current. A small battery has the same voltage as one as large as a house.

But the energy output of the big bonfire is vastly

more than that of the flame of the match. The quantity of heat is greater, will do vastly more work. This is the amperage. The larger battery has larger amperage, or quantity.

We may approach the high tension transformer without fear, notwithstanding its disturbing roar, and thrust a hand into the midst of the foot of shooting sparks. A large vacuum tube, two or three feet in length, with a Geisler tube attached to it, is held in the other hand. The high tension current passes through the body, and both tubes glow brightly. Some electric bulbs will also light up through the body in the same way. Several men can take hold of one another's hands, and then, when I touch my hand to the brass ball of the high frequency coil, the current passes through all of us and lights the tube held in the last man's hand.

It is interesting to note why it is that this current, with a pressure of 200,000 volts, is so harmless, though a commercial current of 110 or 220 volts is painful, and one of 1,000 or 2,000 volts shocks one to death.

Here again the law of resonance is seen in operation. The high frequency current, under a pressure of 200,000 volts, produces a vibratory note which is exceedingly high, several hundred millions of vibrations. The keynote of the human body is a very low one, and does not synchronize with the vibratory rate of the current from the coil, and so does not absorb the energy of that current.

In other words, the body is transparent to that current; and, as we have already seen, discord is

synonymous with transparency. When the pressure is diminished the frequency is lessened also, and as its vibratory rate approaches that of the body, and is in accord with it, absorption takes place, and pain is felt.

The human body is a conductor of electricity, and so is a tree. But neither one is a sufficiently good conductor to pass off a bolt of lightning, and so it is destroyed by the shock, or by the resistance which it presents. Were the body as good a conductor as copper, it would be transparent to the current, and there would be no more sensation than is felt when holding the hand before a bright light and seeing the veins and colour of the red corpuscles. To be a perfect conductor of electricity would mean to be perfectly transparent to it and so discordant with it that it would pass through us as sunlight goes through clear glass.

This is so important a principle that we might truthfully say that, when the rhythm favours, bodies can pass through one another. This is the reason for the unusual statement of the scientist Dr. Thomas Young, that " there are worlds, perhaps, pervading each other, unseen and unknown, in the same space." And Jevons in his *Principles of Science* says: " For anything we can know to the contrary, there may be, right here and now, passing through us, some planet invisible to us, with mountains, oceans, lakes, rivers, cities and inhabitants." Both of these statements are from men of scientific renown.

Of course, such a thing could be possible only as those other worlds and we were so perfectly discordant

that they and we, the other world and our world, could not recognize or respond to one another. Our world would have to be transparent to the other world, and it to us.

We are, perhaps, just now transparent to the spiritual world, as it and its inhabitants are transparent to us. Our natures do not synchronize; there is not a correspondence between them and us, and so we are not able to recognize or detect them by any of our senses. As Drummond states it, we are alive to only that realm or person and thing with which we correspond. We are dead, insensible, to the high frequency current from the Tesla coil, because we are out of tune with it. It were safest and best for us to be dead to some agencies and forces about us.

XVI

THE ATOM

WE have been looking beneath the surface of things about us on earth, and the marvels have been numerous. We have looked off into the skies, past our Galaxy and our universe, and have seen the Island Universes by means of the light which has reached us after its flight for a million years, and we have gained a little conception of what they were a million years ago. What they are now, we hardly dare to guess. They may have vanished altogether or, what is more likely, they may have solidified into planets, and be teeming with life, the home of happy beings like ourselves—without, let us hope, our cataclysm of death and our sorrows from sin.

Now we wish to turn our gaze from the skies, and from things about us, and look to those things which are beneath us a million million times out of reach of our microscope—which lets us see objects 1-7,000th of a millimeter in diameter. Let us reconnoiter 37 trillion, 31 billion times beyond our best spectroscopes, far down among the things the reflection of which we behold in the ultra microscope, twinkling like stars and like stars, too, in that their actual shapes are not delineated, though we see the light that they flash back

to us from the minute, but intense ray which, through a tiny window, was thrown upon them.

We cannot see particles of dust floating in the air, but we can behold their dance when a sunbeam falls upon them; so of those other stars immensely farther away, because of their excessive minuteness. They are the Island Universes in the atomic realm. We shall never see them "until this mortal shall have put on immortality," but we have already learned enough about them to fill us with amazement.

At the present time all scientists are agreed that material things are composed of molecules, atoms and electrons.

The molecules are the smallest particles of a substance which can exist in a separate state and which have the same composition as any larger mass of the same substance. If we separate the atoms of which a molecule is composed, we no longer have the substance but its component parts, which are atoms. For example, if we separate a molecule of water into its component parts, we have two atoms of hydrogen and one atom of oxygen. When an atom of oxygen comes into contact with two atoms of hydrogen it seizes the electron from each of the two atoms of hydrogen; when they are so combined, water is the result.

Molecules being a combination of two or more atoms, they are consequently larger than the atoms; and yet they are exceedingly small. As an illustration of this fact, Dr. Willis R. Whitney recently stated that if of a single drop of water all the molecules should be enlarged until they were as large as drops of rain-

water, they would make water enough to cover the whole earth a foot deep.

As to the size of molecules, Lord Kelvin said that if a single drop of water were enlarged until it became as large as the earth, 8,000 miles in diameter, then the molecules, enlarged in the same proportion, would be larger than a shot, but smaller than a cricket ball.

Dolbear calculated that the molecules are one fifty-millionth of an inch in diameter (that is, fifty million could lie side by side in an inch) and that they have a free path movement from 1,500 feet to a mile a second.

They never rest. They dart about amongst one another with extraordinary activity. As the temperature is increased, their speed increases also. At absolute zero their movements would cease altogether.

The path pursued by a molecule in one second is a zigzag course, divided on the average into 6,000,000,000 little straight free paths between the encounters which it meets with when it touches its next-door neighbour.

In a cubic millimeter of air, at ordinary temperature and pressure, it has been calculated by Dr. G. Johnstone Stoney that there are the following constituents:

31 quadrillion	molecules of	Nitrogen,
8 quadrillion	"	" Oxygen,
16 trillion	"	" Carbon dioxide,
400 trillion	"	" Argon,
400 billion	"	" Neon,
20 to 40 billion	"	" Helium.

Also a small number of Krypton, Xeon and Hydrogen;

about 40 quadrillion molecules, altogether, in one millimeter of air.

"Imagine these enormous swarms of little missiles dashing about in every conceivable direction, each of the missiles successively encountering and occasionally grappling with about 6,000 million of its neighbours every second, and darting along the free path between these encounters with various speeds, but speeds that are so high that they average more than 1,000 miles an hour. The average duration of their vibration is about the six thousand millionth of a second."

Think, then, what we take into our lungs each minute. We breathe on the average once every four seconds; every four seconds we take into the lungs 100 cubic inches of air, or about 2,540 cubic millimeters. If this be multiplied by the forty quadrillion, the molecules in a cubic millimeter, we shall be seen to have ten quintillion of those energetic bodies taken into our lungs with each inhalation. And each one of these is a tiny universe of itself, and moving at a speed equal to or faster than that of our earth.

"If an ordinary electric light bulb, devoid of air, were pierced with an aperture such that one million molecules of air entered per second, the pressure in the bulb would not rise to that of the air outside for a hundred million years."

Now, these molecules consist of immensely smaller bodies, the atoms. Each atom is about one 254 millionth of an inch in diameter. These atoms are the

foundation stones out of which we and the universe are formed. We call them elements.

The electrons within the atoms are still smaller. If a particle the size of an atom were enlarged until it became a yard in diameter, and the electrons within it were correspondingly enlarged, the electrons would be a pin-head in size, and the nucleus of the atom would be 2,000 times smaller still.

Here is a cubic centimeter of steel, as carefully measured as a good mechanic could construct it. With good reason this centimeter of steel is supposed to contain 10^{24}, or one septillion, atoms; and 10^{8}, or one billion extend across each face. If these atoms could be taken out one by one and laid in a row—one 254 millionth of an inch in diameter—they would extend sixty billion miles. It is 2,860,000,000 miles to Neptune; these atoms laid side by side would extend there and back ten times. To count them, one a second, ten hours a day, six days in the week, would take eighty quadrillion years. This statement is easily verified by a simple arithmetical calculation.

"Sands by the seashore innumerable"—innumerable they are, if one should go over and count each one separately. But there are easier methods of calculating the number, at least approximately.

After counting out a thousand of very fine grains of sand, under a microscope, and measuring them in a finely graduated glass container, it was calculated that there are a million such grains of sand in three cubic inches. On the entire earth there are from 350,000 to

500,000 miles of shores, having sand. To be well within the facts, we make the estimate 1,000,000 miles, the average shore 500 feet wide and the sand four feet deep. Then in one mile, of that width and depth, there are eighteen billion cubic inches of sand, or six quadrillion grains of sand. In the one million miles of such shores on earth there are, accordingly, six sextillion grains of sand. But that is a number which is incomprehensible. It would take all the inhabitants of the earth, 1,600 millions of them, 118,750 years to count them at one a second, if no one of them ever stopped day or night.

Yet the septillion atoms in our cubic centimeter of steel outnumber those grains of sand 166 times. In other words, there are as many atoms in that small bit of steel as there are grains of sand by the seashores of 166 worlds like this of ours.

When we make such comparisons as the above, in order to gain a clear conception of how exceedingly minute the molecules are, and then remember that the electrons are only 1-50,000th as large as the atoms, and that the nuclei, or protons, are 2,000 times still smaller than the electrons, one cannot wonder that we termed these bodies the "Island Universes" of the atomic realm. We are standing between two eternities, or infinities, the infinitely distant and the infinitely small; and yet there is something beyond them both. God is in the immensities out there, and that fact makes them small and near. He is also in the Lilliputian universes beneath us, and that fact makes them great.

"The Astronomy of Chemistry" is an expression which is frequently employed by scientists to designate what is occurring within the atoms. Every atom is a perfect solar system in miniature. The central sun consists of the nucleus of the atom, and the planets are the electrons, revolving at different distances and in different planes and at varying speeds around the central sun, or nucleus. The atoms of the different ninety-two elements constitute as many different solar systems; ninety-two different suns, or centres, with various numbers of planets, or electrons, from one, in hydrogen, to ninety-two, in uranium, performing their axoid and orbital revolutions.

The nucleus of the atom until recently was the unknown region. Even now it represents the frontier of scientific knowledge; what lies beyond is mere speculation. As our sun is the great source of energy in our solar system, so the nucleus is regarded as the source of the radioactivity of the atom.

The extreme brilliancy of the sun hides its mysteries from us. It is exceedingly difficult to learn its real nature, the sources of its energy, whether or not it is cooling off, and numerous other of its phenomena. Notwithstanding these barriers which would baffle man in his search for knowledge, he has penetrated into the fiery envelope of the sun and now and again announces some further discovery.

So it has been in seeking to penetrate into the mysteries of the atom, particularly of the central suns. We come to "know them by their fruits," what they do, the things which are projected from them; and so

new and wonderful things are discovered as to their nature and activities.

They are positive electrons, or protons, while the electrons revolving about them like planets, are negative electricity. It is believed that the nuclei do not consist solely of positive electricity but that negative electrons, also, enter into their constitution.

While they are certainly no larger than the electrons—and many believe that they are only 1-1,850th or 1-2,000th of the size of the electrons—nearly all the weight of the atom is due to the nuclei. Indeed, the density of these bodies assumes fantastic proportions. For example, the radius of the gold nucleus must be at least ten thousand times less than the radius of the atom.

Berthoud suggests: "Could we fill the space of a cubic centimeter, about a thimble full, with gold atom nuclei, they would weigh three million tons, enough to load a railway train 1,500 kilometers, or 934 miles, in length, reaching from Naples to Paris," or from New York to Chicago.

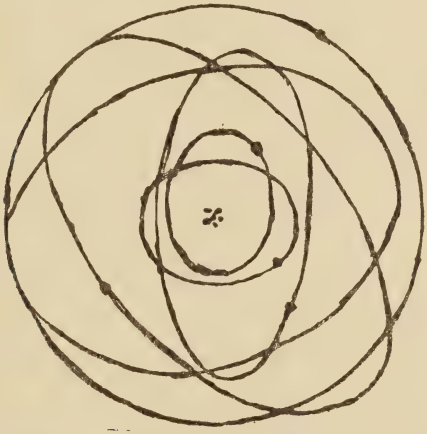
Such a conception of the concentration and weight of matter is incomprehensible to us. We can be aided, however, if we remember that the weight and mass of a thing are relative to the speed of the body. According to this theory of relativity, when the speed of an electron approaches that of light, the mass is well-nigh infinite.

A body moving at a thousand feet a second will fall to the earth much more quickly than one which moves at 20,000 feet a second. The resistance which a body

SUGGESTIONS OF THE ORBITS OF ELECTRONS AROUND THE NUCLEUS OF ATOMS

The positive electrons, or protons, in the nucleus equal the orbits and the negative electrons.

The hydrogen atom. It is the simplest atomic system, containing one proton in the nucleus and one electron.



The carbon atom containing six electrons and six protons.

The helium atom containing two electrons and two protons.

offers to the downward pull of the earth is the measure of its weight.

It has been proven that a column of water only two centimeters, less than an inch, in diameter, falling through a tube 500 meters, or 1,640 feet, high, cannot be broken into by the violent blow of a sabre. "The arm is stopped, as if by a wall, when it arrives at the surface of the liquid. Professor Barnard Brunhes, who witnessed this experiment, expressed the belief that if the velocity of the liquid column were sufficient, a cannon ball would not go through it. A layer of water a few centimeters thick, animated by sufficient velocity, would be as impenetrable to shells as the steel plate of an ironclad."

We have already noticed that the rapid revolutions of a gyroscope impart to it a rigidity which resists the attraction of the earth to such an extent that it will run on a single wire without falling; and if it could be revolved fast enough, it would hold itself in mid-air, at any distance from the earth, wherever it might be placed. Then, as with the earth and other planets, the centrifugal and centripetal forces would be in equilibrium. If the speed were sufficiently increased, it would not only lift itself from the earth, but would lift a ton, or ten tons or any number. Its weight would be increased from, say, ten pounds to perhaps a thousand or million tons, without in any way increasing its size.

It is the speed of the electrons in the gold nucleus which gives them the inconceivable weight mentioned above. The mass of a body has always been regarded

as invariable, while the weight varies with the distance from the centre of the earth. But now, the mass also is seen to be variable, if the theory of relativity be true—as it seems to be.

The number of protons which constitute the nucleus varies with different atoms. In hydrogen there is only one such central sun. Around this there revolves one electron. This is like the earth's moon system.

Oxygen contains sixteen protons and weighs sixteen. Only eight of them exhibit electrical forces; they hold eight electrons in their orbital motions. The other eight protons constitute the rest of the nucleus, and represent its electrical neutral portion.

In radium there are eighty-eight protons and eighty-eight electrons; the eighty-eight active protons at the centre exist along with 137 of the inert electrons. The eighty-eight electrons revolve about the centre, either in ellipses or circles, perhaps both.

It is now thought that radioactivity is due to the explosion of the nucleus, in which α particles and β particles are projected. The nucleus also determines to what element the atom belongs and gives it its weight.

Light is produced when an electron jumps from one orbit to another. An electron may be revolving in an orbit corresponding to that of Mars when it suddenly jumps to an orbit similar to that of Venus or Jupiter or Neptune.

The motions of the electrons around their nucleus is very much like the motion of a flea, which goes on

steadily and then suddenly leaps—to another orbit—no one knows why.

The nuclei are so tiny that an α particle, when

AN IRON ATOM

The iron atom contains twenty-six protons in the nucleus, and has revolving in circles or ellipses twenty-six electrons in as many orbits about the centre.

making its way among the atoms, has very small possibility of encountering a single atomic nucleus.

Radioactivity emanates from the nucleus; whether it be radium or any other radioactive element, there are three kinds of rays, α, β and γ named after the first three letters of the Greek alphabet. The α particles, which produce the scintillations in the spinthariscope, are atoms of helium. The β particles, which revolve in their orbits within the atoms and within the nucleus from which they are ejected, are negative electricity. Their impact in the cathode rays, in the vacuum tube, produces the X-rays. The gamma rays are ether waves, like the X-rays, only more penetrating and more rapid, as will be seen by reference to the Chart of Waves.

Dr. Millikan says: "The radius of an electron cannot be larger, in comparison with the radius of an atom, than is the radius of the earth in comparison with her orbit about the sun. The positive electron—1-2,000th of the size of the negative electron—would be to the size of the negative electron as a sphere having a two-mile radius would be to the size of the earth. The dimensions of the negative and positive constituents of atoms, in comparison with the dimensions of the atoms themselves, are like the dimensions of the planets and the asteroids, in comparison with the size of the solar system.

"A bullet penetrates objects by pushing the molecules aside, but the α particles shoot through all the molecules of air which they encounter, or about half a million, as they have a range of 11.3 centimeters. Practically the whole of the space of an atom must be empty to an electron. The α particle, being an atom

of helium 8,000 times more massive than the negative electron, could no more be deflected by one of the latter in an atom through which it passes, than a cannon ball could be deflected by a flea.

" When we reflect that we can shoot helium atoms by the billion through a thin-walled glass tube, without leaving any holes behind—*i. e.,* without impairing in the slightest degree the vacuum or perceptibly weakening the glass—we see from this alone that the atom must consist mostly of hole; in other words, an atom, like a solar system, must be an exceedingly loose structure whose impenetrable portions must be extraordinarily minute in comparison with the penetrable portions.

" The nucleus is impenetrable. Occasionally an α particle hits the nucleus ' head on,' and when it does so, it is turned straight back on its course."

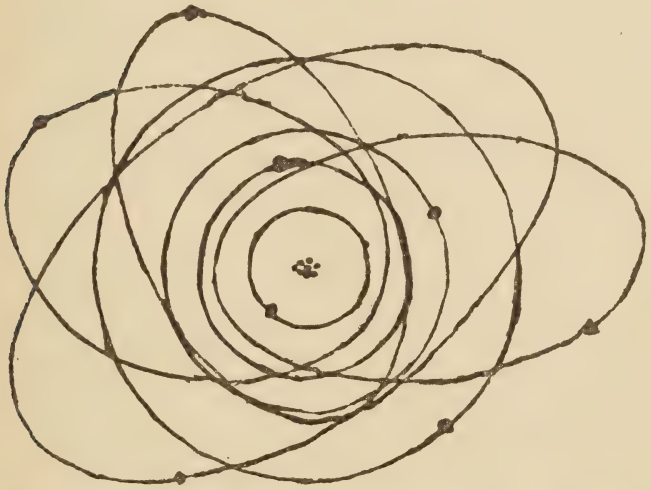
The speed of their revolutions makes the electrons in the nucleus too rigid for the α particles to penetrate their family circle. They are a marvellously compact little clan, composed of positives and neutrals, and are subject to some kind of clannish jars; for one of their number, now and again, is expelled with great velocity equal almost to the speed of light.

According to Bohr, the first or innermost orbit of the electron in a hydrogen atom has a radius of 0.55×10^{-18} centimeters, while the next orbit is four times this radius, and so on. The electron travels around the innermost path 6.2×10^{15} times a second, or six quadrillion, 200 trillion times, and is therefore

moving with a velocity of 2,000 meters, or 6,562 feet, a second; but the negative electrons ejected from radium travel from 3-10th to 98-100th of the speed of light; that is, up to 182,000 miles a second.

From what has already been said it will be seen that the different elements are different systems, planetary in their motions. Each element has its own central sun, with planets and comets revolving around it.

AN OXYGEN ATOM
(See page 217)



The oxygen atom with its eight planetary electrons revolving about its central nucleus is a system very similar to our solar system with its central sun and eight attendant planets. The latter however has several hundred asteroids between Mars and Jupiter.

In the subjoined table of the elements the names of the systems are given. There are ninety-two such systems, but two have not yet been discovered, and

one is only known at this time as "No. 61." It was discovered in March, 1926. We know that there are two others, numbers 85 and 87, just as it was known from calculations by Leverrier that there was a planet beyond Uranus, which Galle discovered. So we know the places of these undiscovered elements in the system and the number of electrons in each atom.

The position of an element in the periodic table is called its atomic number. Physicists regard atomic numbers as being the number of units in the nucleus of the atom. The number of positive electrons, or protons, in the nucleus is equalled by the negative electrons which revolve in their orbits about the nucleus. "Just now," says Millikan, "there is increasing evidence that the number of free negative electrons in an atom determines the chemical affinity of the atom and, indeed, all its chemical and physical properties, except its weight."

Hence, by reference to the table one can determine the number of both positive and negative electrons in an atom, by the number or place the element has in the system. This, however, does not determine the number of neutral electrons in the nuclei of the various atoms.

TABLE OF ELEMENTS

Element	Atomic Number	Symbo	Atomic Weight
Hydrogen	1	H	1.008
Helium	2	He	4.
Lithium	3	Li	6.94
Glucium	4	Gl	9.1
Boron	5	B	11.
Carbon	6	C	12.
Nitrogen	7	N	14.01
Oxygen	8	O	16.
Flourine	9	F	19.
Neon	10	Ne	20.22
Sodium	11	Na	23.
Magnesium	12	Mg	24.32
Aluminum	13	Al	27.1
Silicon	14	Si	28.3
Phosphorus	15	P	31.04
Sulphur	16	S	32.06
Chlorine	17	Cl	35.46
Argon	18	A	39.88
Potassium	19	K	39.10
Calcium	20	Ca	40.09
Scandium*	21	Sc	44.1
Titanium	22	Ti	48.1
Vanadium	23	V	51.
Chromium	24	Cr	52.
Manganese	25	Mn	54.93
Iron	26	Fe	55.84
Cobalt	27	Co	58.97
Nickel	28	Ni	58.68
Copper	29	Cu	63.57
Zinc	30	Zn	65.37
Gallium	31	Ga	69.9
Germanium	32	Ge	72.5
Arsenic	33	As	74.96
Selenium	34	Se	79.2
Bromine	35	Br	79.92
Krypton	36	Kr	82.92
Rubidium	37	Rh	85.45
Strontium	38	Sr	87.63
Yttrium*	39	Y	88.7
Zirconium	40	Zr	90.6
Columbium	41	Cb	93.1
Molybdenum	42	Mo	96.
Masurium	43	....	.....
Ruthenium	44	Ru	101.7
Rhodium	45	Rh	102.9
Palladium	46	Pd	106.7
Silver	47	Ag	107.88

TABLE OF ELEMENTS—*Continued*

Element	Atomic Number	Symbol	Atomic Weight
Cadmium	48	Cd	112.40
Indium	49	In	114.8
Tin	50	Sn	118.7
Antimony	51	Sb	120.2
Tellurium	52	Te	127.5
Iodine	53	I	126.92
Xenon	54	X	130.2
Caesium	55	Cs	132.81
Barium	56	Ba	137.37
Lanthanum*	57	La	139.
Cerium*	58	Ce	140.25
Praseodymium*	59	Pr	140.9
Neodymium*	60	Nd	144.3
"No. 61"	61	....	.....
Samarium*	62	Sa	150.4
Europium*	63	Eu	152.
Gadolinium*	64	Ga	157.3
Terbium*	65	Tb	159.2
Dysprosium*	66	Ds	162.5
Holminum*	67	Ho	163.5
Erbium*	68	Er	167.7
Thulium*	69	Tu	168.5
Ytterbium*	70	Yb	173.5
Lutecium*	71	Lu	175
Hafnium	72	Hf	.....
Tantalum	73	Ta	181.5
Tungsten	74	W	184.
Rhenium	75	....	.....
Osmium	76	Os	190.9
Iridium	77	Ir	193.1
Platinum	78	Pt	195.2
Gold	79	Au	197.2
Mercury	80	Hg	200.6
Thallium	81	Tl	204.
Lead	82	Pb	207.20
Bismuth	83	Bi	208.
Polonium	84	Po	.....
.....	85	....	.....
Niton	86	Nt	222.4
.....	87	....	.....
Radium	88	Ra	226.
Actinium	89	Ac	.....
Thorium	90	Th	232.4
Uranium XII	91	Ur XII	.....
Uranium	92	Ur	238.2

*Rare Earths.

XVII

THE ATOM AS A TYPE

ONE can hardly find a book which deals with the atom, its structure and the operations within it, without noticing the often repeated expression, " the solar system," with other astronomical terms, applied to the atoms.

The parallels between things astronomical and things chemical cannot be imaginary or trifling, to be so generally recognized and referred to. Indeed, these similarities are most marked, and they are fascinating.

The small size of the atoms does not invalidate such a comparison. In an immensity without limits, extreme littleness does not sensibly differ from extreme greatness. Beings sufficiently small would regard their world systems, formed from atoms and electrons, as important, as to us are the mighty suns and stars in the ethereal realms above us.

What is only the wink of an eye to us would be hundreds of millions of years to them, their planets making that many orbital revolutions in that time. Likewise, the " three score years and ten " of our life are but a single second to those who dwell in those worlds whose orbital revolutions require many millions of years.

After men have studied the skies for many centu-

ries, kept their nightly vigils without relaxing, spent days, months and years in calculations and comparisons, ever inventing new and better aids to vision, they are rewarded in this late day by having the nebulæ give up some of their secrets. The photographic plate has proven to be an eye which can gaze through a powerful telescope for many hours at a time without weariness, never failing to note any change with precision, and do this month after month.

Notwithstanding this fact, if those distant suns did not shine a thousand times brighter than our sun, they would have no chance of being found on any of our photographic plates.

The Island Universes of the Nebula of Andromeda shine a billion times brighter than our sun—and some others are still more distant, more than a million light years away. And yet they are obeying the same laws, passing through similar revolutions and moving at similar rates, meeting the same catastrophes, yielding up vast stores of energy, such as we discover in the atoms of matter all about us.

It has been found that the sun has a positive, though small electric charge, and the earth a negative charge. So the sun corresponds precisely to the nucleus of an atom, and the earth to one of its revolving electrons. The sun shoots off free electrons, mingled with positive particles. According to Arrhenius, these are sorted out by the earth's magnetism, the positive protons falling mainly at the tropics and the negative electrons being deflected to the poles, where they appear as the aurora.

The ratio of the masses of atoms and planets is very interesting. The mass of Jupiter is about 1-1,000th of the sun, and approaches the mass of an electron in comparison with a hydrogen atom, the mass of which is 1-1,835 times that of an electron.

The mass of the earth is 1-324,000th of that of the sun, and this ratio is nearly the same as that of an electron to the atoms in the heavier elements, like gold, mercury and lead.

The ratio which exists between the dimensions of the solar system and its planets, and the atoms and electrons, is very striking. This also holds true with reference to the distances and velocities.

A single example will illustrate these wonderful similarities. If we should reduce the visible Galaxy so that it would be of microscopic proportions, it would be about 10^{22} to 1. The radius of the solar system is about 10^{14} cm. If this be divided by 10^{22}, we have 10^{-8} cm. the radius of an atom. These, with many other like calculations, reveal the interesting fact that if we could increase the size of the atoms and electrons to astronomical proportions, we would have what we see in our solar system and in other stellar systems.

On the other hand, could we reduce the universe to the size of a molecule we would have, in the stars and their consorts, the atoms and electrons in the familiar things about us.

To see a molecule of ordinary pitchblende with all its derivatives—gas and the multiplicity of elements—as they really are, diverse atoms holding fast to one

another, by the pull of their attraction, yet never touching one another, each elementary system having its suns and planets, asteroids and comets, and all revolving on their axes, and in their orbits, in perfect precision, so that if you look at them today, and then a year from today, you find them always keeping their own relative positions and as readily identify them as you can the Big Dipper or the North Star; to witness their radiations, comets and meteors, and other operations is to see a miniature of the Milky Way, with its suns, planets, double and triple stars, Pleiades, Orion, Cepheid variables and ten thousand other complexities and mysteries.

The celebrated scientist, H. Henri Poincaré, compared the countless suns of the Milky Way to the molecules of a bubble of gas, applying to them the kinetic theory and opening in the stellar universe astonishing aspects.

The disruption of atoms, as in radium and in the temporary stars, nova, which astonish astronomers as they flare up with a light which shows a radiation of as much energy in six months as that of the sun in a million years, are both outbursts of radioactivity. The same processes are operating.

In the famous Nova of 1885, which had a luminosity 400 million times that of the sun, there was a head-on collision of an electron, or alpha particle, with the nucleus of the atom in that far off system.

All the cells of our bodies are composed of these same atoms. A cell is a solar system. A blood corpuscle is a starry galaxy or a spiral nebula. The

THE PLEIADES

Photograph taken at the Lick observatory, and used by permission. The group is 325 light years distant from us, and the stars are so numerous, probably 2,500, that the group is thirty light years in diameter. To the naked eye it appears as a small Y in the heavens. Alcyone is the bottom star. (*See page 231.*)

rupture of brain cells in mental activity means the ejection of electrons to travel along the nerves and through the muscles in vibratory impulses.

The disruption of cells to release energy for work, and the casting off of the waste products, the ashes of the conflagration within us, are the processes of radioactivity on a large scale. The human body continually emits infra-red radiations, and all living tissue is radioactive.

What has been termed the Electronic Reaction method in the treatment of diseases, by its author, the late Dr. Albert Abrams, has created no small stir and much controversy. It has been attacked vigorously and denounced as a deception, but just as strenuously defended by its advocates.

The scientific principle that all bodies, great or small, all cells, atoms and disease germs, and drugs as well, have their vibratory rate, or keynote, is the foundation on which this method in medicine is built. Creating electrically the vibratory rate of a disease germ over it tends to disintegrate and destroy it.

Whether or not the instruments devised do create the actual vibratory rate of bacteria and destroy them, we do not know. There can be no doubt, however, that all cells and atoms, whether in the body or out of it, have their definite rate of vibration, or keynote, and that sooner or later this principle will be scientifically utilized for the cure of disease.

Every one of us carries about within himself vast complexities of Galaxes, Island Universes, Constellations, fixed stars, planets, moons and all else that exists

in the heavens above. We are a compendium of the whole creation. The atoms, with their electrons and protons, point to us as a universe of which they are the prototype.

A pin prick pierces into many a solar system in our universe. The starry heavens are our brothers, "bone of our bone and flesh of our flesh," and so we feel "at home among the stars." We love to look at them. They are like us, only not at all so complex and wonderful.

We are accustomed in these days to speak of our Galaxy as our universe, and of the Island Universes, the universes in Triangulum, and so on. But the universe is one. One form of construction, one law running through it all; one Thought moulds and controls it all. One Design and Purpose are manifest in it all.

> One God, one law, one element,
> And one far off divine event
> To which the whole creation moves.

Professor C. A. Young, for many years the head of the department of astronomy in Princeton University, confessed: "If I were to say what I really believe, it would be that the motion of the spheres of the material universe stands in some such relation to God, in whom all things exist, as the motions of my body do to my will. I do not know how, and never expect to know."

Here we stand in the midst of the universe, our body. We will, and suns and planets obey our behests. When the worlds which compose our physical frame are nicely balanced, and speed on smoothly in

DIFFUSE NEBULA AROUND MEROPE IN THE PLEIADES

Merope is the large central star at the right in the plate of the Pleiades, page 233. Taken at Mount Wilson observatory, and used by permission. Exposure five hours.

(*See page 231.*)

their orbits and whirl on their axes without a jar, all is well with our system; we are in good health. When there is a disturbance of the molecular equilibrium in the cells, tissues and organs of the body, we are diseased; and that something which is needed to perfect the balance must be added to restore in us the equilibrium between the opposing forces, the centrifugal, or casting away, and the centripetal, or drawing inward; the tearing down and the building up processes.

To disturb the equilibrium in our solar system, and among the stars would cause instant confusion and calamity, pandemonium and despair; wailing would ascend from every sentient creature. It would be like a fatal disease in the body or like sin in our moral nature.

Thus far we are safe, for our Father, revealed to us in Christ, dwells in His body, as we dwell in ours. He created all, is at the centre of all, and around Him all things move; His will is done in heaven, and at some time the earth shall know the joy of having it perfectly done here.

God is the centre of gravitation of every conceivable universe. Our sun and its attendants are travelling away from the Constellation of Orion, toward the Constellation of Hercules, at the rate of eighteen miles a second, or more than 550 million miles a year. Arcturus is coming toward us at the rate of sixty miles a second, or 1,800 million miles a year.

Mäedler held that Alcyone, the central sun of the Pleiades, is the centre around which our solar system moves. Whether or not he was mistaken we cannot

say, but it is certain that our system is travelling through the heavens, around a centre, at the rate mentioned above, and that the Pleiades, as a cluster of systems, along with countless other systems, are revolving around the one far-off centre of all systems—the " great white throne " of the Eternal and Infinite Creator, our Saviour. Arcturus is a gleaming badge on the breast of our God.

XVIII

THE TRINITY OF SCIENCE

SOME years ago a most interesting address was delivered in Manchester, England, by Dr. Arthur T. Wilkinson on the subject, "The Witness of Physical Science to the Triune God." He stated that his attention had been called to the thoughts, which he would enlarge upon, contained in a book published long before, in 1882, *Light,* by Lewis Wright.

This incident means that the testimony of science to the triune God was recognized and discussed more than forty-five years ago. Since that time, however, astonishing discoveries have been made concerning the atom, its radioactivity and its interior constitution. All these discoveries have confirmed, re-enforced and emphasized the truths so long ago enunciated by Dr. Wilkinson and others.

We have already dwelt on the oneness of the universe, and on the fact that this oneness indicates the unity of its Creator.

This is the truth which is taught and reiterated in the Old Testament Scriptures. The Hebrews being surrounded by idolatrous nations, in such an environment they were continuously prone to engage in the worship of many gods. So the first note struck, and

continuously maintained as fundamental, by all the prophets is the unity of God. "Hear, O Israel, the Lord our God is one Lord."

But, as revelation developed, there was more and more unfolded the fact that the unity of God is a tri-unity. The doctrine of the Trinity is an induction from Scripture statements as a whole. It has been held by the great majority of Christians for more than 1,500 years. Each person received into the Church is baptized into "the name of the Father and of the Son and of the Holy Ghost," and the Gloria ascribes praise to God in similar words.

God the Father, in essence the infinite Spirit, dwells "in the light unapproachable, whom no man hath seen or can see"; He is the omnipotent, the centre and the source of all things, and He transcends all ideas of time and space.

He manifests Himself in a second Person, derived from the first and coeval with Him. The second Person is the "radiance of the Glory of God and the very expression of his being, upholding all things by the power of his word."

He who has seen Christ has seen the Father, also. "He it was who for us men, and for our salvation, took to himself our nature," became the God-man, died for us and rose again, and is now our living and glorified Lord. He will again reveal Himself to the world in His glory.

The third Person of the Holy Trinity is the Holy Spirit. He is not a mere influence, but is a person proceeding from the Father and the Son, with whom

He is equal and co-eternal and infinite. He is the Power from on high; the regenerator, purifier and inspirer of men's lives. By Him, Christ wrought all His marvellous works, rose from the dead and was glorified.

The doctrine of the Trinity is not a surface truth. It is the result of profound study and reverent deductions from Scripture statements. It has been the source of discussions and of no small controversy. Its advocates have never contended that it is not mysterious and incomprehensible; the method of the existence of the Infinite God could not be otherwise.

This difficulty, however, should not disturb us overmuch, for we live in an environment which consists of the works of God, nearly all of which are not only mysterious but are utterly inexplicable. The most learned scientist knows no more of the how and why of gravitation than the simplest Christian believer knows of the nature and mode of God's existence; yet we all are subject to the influence and power of gravitation all our lives. Every act of ours must have some reference to this omnipresent but inscrutable force.

Science declares that matter, the ether and force, in their every conceivable expression, are a unity but, also, that they are a trinity. Dolbear entitled his book, *Matter, Ether and Motion.* But this title reverses the order of their existence. Matter is a form of motion of the ether, and so the ether must have existed prior to matter. The atom is a form of energy; then energy must have existed before matter. The correct order is: Ether, Energy, Matter.

No such thing exists as empty space. There is something which fills all space, which is a medium for the transmission of light waves for millions of light years from the regions beyond the Island Universes. Because of this fact, it was at first termed the luminiferous ether; but since it is now known that all kinds of energy pass through it, and originate from it, the term ether now is employed.

The less air there is in an electric light bulb, the more readily the light waves pass through it. Hence it is not the air, or matter, which is the medium for light waves. Besides, the air at most does not extend more than 200 miles above the earth. Light waves traverse space devoid of air.

The ether does not appeal to any of our senses; we cannot see it, feel it, taste it, or hear it. It is intangible, imponderable, omnipresent, illimitable. We cannot get rid of it. In it we live and move and have our being. We are expressions of it, its offspring. It has no form nor shape; rarer than any gas, at the same time, it is more rigid than steel. We cannot explain it, and we cannot explain the universe without it—we must have it.

The first thing of which we became conscious in this world was matter. We saw it and touched it, but we could not understand it until, by faith, we had discovered the ether. And now that which was last has become first. Ether, this strange something, is not wholly reducible to the rules of mechanics.

Faith in the unseen is not an exclusive characteristic of the Christian. It seems to me that Christ

would say to the average man of science: "O man, great is thy faith!" The mystery of the ether does not prevent our study of it. It is filled with real though invisible light; and though it is never presented to our senses, it is the great reality.

It is hardly necessary to say that the Infinite Father could hardly have more perfectly translated into a time symbol, His essential nature as infinite Spirit.

The second declaration of the physicist is: "I believe in matter." Now we come to something definite. We can see matter, feel it, taste it. It is something substantial. We can weigh it, handle it and do marvels with it. We ourselves are made of it. We are so familiar with it that it seems most simple to us.

Yet ask the scientist what matter actually is, and he will say that it is a profound mystery. It is composed of atoms, electrons, protons, ether and energy. But they all are the same. Matter is ether manifested; from ether it is continuously and eternally generated—as we witness in radioactive substances like uranium and radium. This deep mystery illustrates the fact that the simplest things may be most profound and mysterious.

This second "person" of the trinity of science, matter, is the incarnation of the first "person," ether. Ether and matter are identical; in no way are they two separate entities. They are one thing under different forms; we cannot put them asunder.

We should never have suspected the existence of the ether, much less understood it, had it not been for the revelation which matter had made to us of it.

The universal attraction of matter is one of its characteristics, and this and all the other characteristics remind us of the Son of Man, Who said: "And I, if I be lifted up from the earth, will draw all men unto me."

The third "person" of the trinity of science is energy. That is the name by which all forces are designated. All energy is one. We cannot create it or destroy it. According to the law of the conservation of energy, when energy disappears in one form, it appears in another. It has as real an existence as matter. It is the manifestant of the ether by means of matter. Energy reveals matter; for example, light reveals the sun. Were it not for energy, we could see nothing, taste nothing, feel nothing. Energy is the great revealer. In gravitation, it is instantaneous and unlimited. By it we have all our blessings—our light, heat, telephones, radios, automobiles and every other convenience or necessity.

I need hardly add that this third "person" of the trinity of science reminds us of the Third Person of the Holy Trinity. In using the terms which are descriptive of the existence and relation of ether, matter and energy, it seems as if I were writing a description of the being and relation of the Father, Son and Holy Spirit. Here is more than a mere figure of speech. Nature reveals its Author as a painting reveals the artist or a machine its inventor—only vastly more accurately and fully. The revelation takes place somewhat as a son reveals his father.

The ether, matter and energy form one universe; all

are different, yet the same. This is a mystery so profound (and yet unhesitatingly confessed by the scientist) that no theologian need feel that his faith in the triune God, Father, Son and Holy Spirit, is something for which he needs to apologize. Faith in the reality of the one trinity is as rational as faith in the other.

Without doubt God intended that the universe should reflect His own being to all who trust Him and who in faith—the faith of the scientist—seek for Him.

The full significance, beauty and grandeur of Nature never dawn upon us until we view Nature through the eyes of God.

XIX

RADIUM DISCLOSURES

THE energy of radium is so tremendous that Soddy says if one-half grain of pure radium bromide were divided among all the people on earth, the amount owned by any one person could be easily detected. One three billionth of a gram could be recognized in the laboratory. No sun or star is giving out so much energy, at a rate relative to its mass, as that given out by radium.

"A pint of the gas radium emanation, to obtain which a ton of pure radium bromide would be required, would radiate the energy of a hundred powerful arc lamps. No vessel would hold it. Such a quantity would instantly melt and dispel in vapour any material known."

In every substance in which radium ever is found it exists in one part of radium to every 3,200,000 parts of uranium. So the ratio of the life of the two elements is this: For radium, 2,500 years; for uranium, 8,000,000,000 years.

The mysterious source of the energy of radium is frequently mentioned by those who have specialized in its study. "It draws its supplies of energy," says Soddy, "from an hitherto unknown source and obeys as yet undiscovered laws. There is something sublime

about its aloofness and its indifference to its external environment. It seems to claim lineage with the worlds beyond us, fed with the same inexhaustible fires, urged by the same uncontrollable mechanism which keeps the great suns alight in the heavens over endless periods."

It gives, gives, gives without ceasing, and it has been doing so during all the countless ages of its existence. Nothing can accelerate or retard its giving. Where does it get all its energy? What is the source of its power? It seems so simple; a child can handle it. When we see it it appears to be like a tiny pinch of salt, slightly tinged with violet. We can handle the pitchblende, carnotite and other ores in which it dwells, and throw them about as we would any common stone; yet there is resident within them inconceivable stores of energy. The fires of the suns blaze within their secret natures. So simple, yet they are so profound in mystery.

How all these are like the descriptive characteristics of the Son of Man! He was a carpenter. He grew up with His brothers and sisters. Men knew Him, and were astonished at the marvellous forces which emanated from Him. Where did He get all this wisdom? No university gave Him degrees. Whence came all His marvellous deeds; how could He heal the sick, give sight to those born blind, even raise the dead? In other words, what was the source of His power?

When we look upon a single gram of matter and are told that that tiny thing represents as much

power as would result from the burning of 3,300,000 tons of coal, we cannot realize that such a thing is possible.

Matter derives its energy from the Author of all things. He must be the source of our energy, too. Jesus said: "As the Father hath life in himself, so hath he given the Son to have life in himself." "I do nothing of myself." "I proceeded forth, and came from God." "I and my Father are one." "All power is given unto me in heaven and in earth."

Because He is what He is, radium is what it is, the suns are what they are, and all the transcendent forces of nature are what they are. They exist in and by Him. This is a conception of nature which makes all things clear; and apart from this, the world abounds in inexplicable mysteries. Why should one go with Romanes step after step through inductive processes and experiments in nature, and arrive at last at the point where he says, "Tap nature anywhere, and it seems to flow with purpose," yet then hesitate to take the other step which unhesitatingly welcomes the Author of all things—Who purposes our good, and our eternal blessedness, in union with Himself through Jesus Christ?

Another disclosure of radium is its inductive power. Madame Curie says: "We have found that any substance placed in the neighbourhood of radium acquires a radioactivity which persists for many hours, even days, after the removal of the radium. This induced radioactivity increases with the time during which it is exposed to the action of the radium, up to a certain

limit. After the radium is removed it decreases rapidly and tends to disappear. The kind of substance exposed to the action of the radium is almost a matter of indifference; they all acquire a radioactivity of their own."

Everything brought into the presence of radium starts into activity, and gives out rays comparable to radium in affecting photographic plates and in discharging electricity.

It is not known just what causes this phenomenon—whether it be an impartation of the radium, so that a film of radioactive matter envelops the object, or whether it be due to the powerful excitation of the atoms of the substance so affected, so that they vibrate in unison with the exciter, as in the case of willimite, which phosphoresces in the presence of exceedingly small portions of radium or under the bombardment of the cathode rays. Perhaps both these causes operate to produce these results.

We know that all matter to some extent imparts somewhat of itself to its environment. One need only touch matter to draw electricity from it. In a dry atmosphere, which is a good insulator, to stroke the fur of a cat or to comb one's own dry hair is to produce electric sparks. One light touch of a catskin is sufficient to electrify a piece of insulated metal to a potential of several hundred volts.

"Without any exaggeration at all," says LeBon, "we can assert that a body cannot be touched without heat coming forth from it." This tendency of all matter to impart some of its energy, though feebly,

to all its surroundings is a very marked characteristic of radium.

Here again nature reveals, however slightly, yet in some degree, the characteristics of its Creator. No one could have come into the presence of Jesus and not feel the force of what He was. And those who had confidence in Him needed but to touch the hem of His garment to have virtue pass from Him to them.

This was not merely an influence which was exerted over the minds of the people by a pure and noble man. Napoleon Bonaparte prophesied that after his death his influence over his fellow-men, would return to France, and would there be manifest in ever-recurring revolutions. For a short time his influence over his countrymen was indeed very great, but that influence has steadily waned; today we may say that it has practically ceased altogether.

That is very far from being true of Christ. He was never felt so powerfully in the lives of men as now. By the million men would, if need be, lay down their lives in His behalf.

And though He makes no appeal to our senses, He is so present in the consciences of men that to think of Him can dispel temptation. Crimes cannot be committed when He is felt to be near. Evil thoughts—revenge, anger, lust, cruelty—vanish just in proportion as He is brought to mind.

When He induces His thoughts within the lives of His followers, and is reflected in their conduct, they in turn take on His characteristics and become "radio-active" with His qualities. Most sons find it almost

impossible to think evil in the presence of their pure and holy mothers. Men in all generations have so partaken of the power resident in Christ that their fellows have been wont to ask: "What is the source of their power?"

Their ability and skill are not commensurate with the results which flow from their efforts. Apparent trifles, as both said and wrought by them, are followed by effects which are quite out of proportion to the apparent causes.

Fifty years ago men were inquiring as to the source of the power of D. L. Moody over his fellow-men. So they are inquiring in reference to some men and women in this generation. Others, though more learned, better equipped in all visible ways and endowed with greater natural talents, seem impotent, while these simple folk have but to speak, and the power of prejudice ceases, hatred vanishes, good resolutions and tears of repentance replace debasing desires and lives are transformed.

The Power from on high has been induced within them; so they show forth the energy of Him who stilled the storms on Galilee, and still assuages the evil passions of men.

Such people seem to be Rare Earths—strange elements which are marked with a star in the Table of Elements in this book.

Most of us are constituted of rather common clay. This fact is important, for even common clay in some measure is radioactive. There is no one who does not impart something to his environment. We all change

more or less in the presence of different persons, and that in accordance with their character. Some awaken our vanity or pride or selfishness or boastfulness, or they may simply degrade us morally. Others make us to desire the best things, purity, generosity, patience; to be forgiving and Christ-like.

And the inductive power which others work in us we also induce in others. No one can be in our presence without being better or worse, for no one can touch us without having something of ourselves imparted to him. God has so constituted nature that no portion of matter can exist anywhere without imparting something to its environment; and we are matter, plus mind and conscience and will and affections. The fact that we constantly impart something to others may be one reason for our sense of weariness after having been in the presence of others. We give somewhat to every one whom we meet on the street. How fortunate it is if we emulate the greatest of all Givers, who delights in giving only that which is good!

We devoted considerable attention, in describing the various experiments in a previous chapter, to the law of resonance, as manifested among the atoms of matter as well as in the electro-magnetic ether waves in radio phenomena. All atoms have their vibratory rate, as well as their revolutions; and consequently they have their keynote. Because of this fact, that which is invisible becomes visible, as we saw in the various stones which, under the impact of the ultra-violet rays, revealed their atomic vibrations in their colours.

So we might add that not an atom exists anywhere, not a molecule or cell, which is not subject to this law. We ourselves, and the health-giving bacteria—but the poisonous ones as well—all have our keynote. And what we are, helpful or injurious, depends upon the note of our inmost nature.

Our peace here in God's creation, and our welfare in the ages to come, will depend upon our note. A song of praise in unison with God and His nature, or else a clash of discord, is what each one must choose to become.

XX

THE CONSERVATION OF ENERGY

THE Conservation of Energy is the doctrine that the sum total of the energy of the universe neither diminishes nor increases, though it may assume different forms successively. For example, coal is burned; the burning releases energy as heat; this heat expands water into steam; this steam turns the wheels of an engine; this engine moves an armature before an electro-magnet; this movement causes the appearance of an electric current, which may be seen as light, or possibly as mechanical motion in a motor; and power runs a street car; and this energy in the car is again turned into work, or mechanical force, and into heat, produced by the friction of the brakes on the car wheels. And so we might continue to trace the processes and the media; but the energy, though it has been transformed, has in no case been annihilated.

An electric current passing over a wire causes an electric flux around the wire, and a magnetic needle brought near to this turns and stands across the wire. What the current does in the region near the wire, it also does among the atoms of the wire or in those of a piece of iron. The atoms, being tiny magnets, with their positive and negative poles, swing around and

take direction in harmony with the force moving them.

This is true of the atoms of material objects generally, such as all wooden and metal musical instruments. They arrange themselves in accordance with the musical vibrations played over them.

Doubtless here is one reason for the numerous beautiful rhythmical forms everywhere assumed in nature, such as crystals, ferns, leaves, flowers and the beautiful patterns in frost and in snowflakes.

In living vegetable products the marvellous vibrations in sunlight, from the low infra-red up through the prismatic colours far into the ultra-violet, play over the atoms which are being woven into existence by the vibratory vital forces of the plant or tree, and beautiful visible forms result.

Lowering the temperature of watery vapour acts on the water molecules somewhat as a magnetic current acts on the atoms of iron. Just before the water congeals it expands, and the atoms, being separated more widely and being less crowded, are afforded an opportunity to turn about among one another and to arrange themselves in accordance with the attracting and repelling forces within them and the rhythmic vibrations at play about them.

The vital forces in a tree or plant which add molecule to molecule, in forming cells for the growth of leaves and flowers, are of a vibratory character which have their own peculiar and characteristic keynote; so plants, leaves, flowers and fruit, as they are being formed, swing themselves more and more into harmony

with their own internal music and of that in the sunlight playing upon them.

It is doubtless true that no musical instrument played by the skill of man ever discourses such perfect music as is being produced in nature's conservatory by the crystals, ferns, flowers and frostlike patterns, under the spell of their own atomic vibrations, accentuated and moulded by the etheric waves falling upon them from the sun and the surging to-and-fro vibrations in the atmosphere.

Paulsen's Telegraphone is an illustration of how vibrations may be locked within the heart of a piece of steel. Words are spoken or sung into a telephone terminating in a tiny electro-magnet with a needle point. This rests upon a steel wire, or a steel disk, which is revolving. The electro-magnetic needle magnetizes the atoms of the steel passed over, and these swing around into harmony with the magnetic waves falling upon them; being closely crowded together, as they are in the steel family, when once they are forced into a new position they can not easily turn back again into the old one from which they were twisted. They must wait for the same master hand which put them there to touch them again; but on the instant they return the compliment and remagnetize the needle point; this moves the diaphragm of the telephone, and the atoms of steel are heard singing the song which was sung into them.

Among his lectures on science, delivered over a period of twenty years or more, the author had one on the conservation of energy. In this lecture he

caused the energy of his hand or of his voice to pass through numerous transformations, and at last return to the room whence it started, where it was recognized by the audience as the same as that which had started on its journey. Then, by a series of charts of the apparatus used, he pointed out the various operations of the energy and also the media through which it passed in its intricate excursion away from and back to the sender.

A radio transmitter consisting of a microphone and transformer is installed in an auditorium. Words are spoken into the microphone and are transformed into ether waves, pass through the walls of the building, across an intervening space into another building, and there are detected by the radio receiver; the words as air waves from this instrument fall upon the disk of another carbon telephone, and are transformed into electro-magnetic impulses, which pass over a wire which leads to another building. There the words are received through a telephone earpiece, and these vibrations fall upon the telephone mouthpiece of Paulsen's telegraphone. These vibrations are telephoned to the tiny electro-magnet which rests upon a revolving steel disk. As soon as the words cease the magnet on the disk is shifted and placed at the beginning of the speech, as is done in a victrola, and the tones of the voice are reproduced, and are received by a dictograph or carbon telephone and are telephoned over a wire from that building into the auditorium whence they originated. There they are heard by the audience as coming from a horn at the other

end of the platform—the same words, intonations, inflections and all, as when they began their pilgrimage.

That it may be seen how intricate and complicated is the course which energy takes in its journey, we will follow out, for the sake of brevity, the steps in one of the first and simplest of the experiments referred to, experiments designed to illustrate the conservation of force.

A simple wireless telegraph instrument, having a coherer as detector in the receiver, with a bell connected to it, was employed. The wireless message was sent to a second building, from that to a third one, and from there was returned to the audience room of the sender. We will note its transformations.

There was an act of the will to speak, and then a rupture of brain cells, releasing energy. This energy caused:

1. An impulse along the motor nerves.
2. Muscular contractions, producing pressure on the wireless key.
3. Pulsatory currents in the primary winding of the induction coil.
4. Undulating magnetic force produced in the iron core of the coil.
5. Alternating currents in the secondary winding of the coil.
6. Minute eddy currents appearing in the wires of the primary and secondary windings of the coil and in the iron core.
7. Heat produced by these eddy currents.
8. Magnetic hysteresis in the iron core—in other words,

inertia—a disposition of the atoms to resist movement formed in overcoming molecular friction in the iron caused by reversals of its polarity.

9. Heat produced by the hysteresis in the iron.
10. Infinitesimal variation in the length of the iron core due to the magnetizing currents.
11. Moving electrostatic flux on the line, accompanied by or producing electro-magnetic flux around the wires leading from the secondary of the coil to the brass balls.
12. Electric waves produced between the brass balls, shocking the ether of space.
13. Ether waves transmitted through space and the walls of the building.
14. The conversion of the coherer, overcoming the hysteresis of the metal of the filings, causing the atoms to rearrange themselves, in accord with the electric current in the battery wires, and make them of the same keynote as that of the ether waves.
15. Pulsatory current in the wire leading to the relay.
16. Heat produced by the passage of the eddy current through the wire of the relay.
17. Undulating magnetic force produced in the iron cores of the relay coils.
18. Magnetic hysteresis in the iron of the cores.
19. Heat produced by the hysteresis in the iron.
20. Infinitesimal variation in the length of the iron, due to the magnetizing currents.
21. Movement of the armature of the relay, closing the relay circuit.
22. Electric pulse on the wire of the bell circuit, producing electro-magnetic flux around the wire.
23. Heat produced by the passage of the current through the wire.
24. Undulating electro-magnetic force produced in the iron of the electro-magnet of the bell.

25. Magnetic hysteresis in the iron.
26. Heat produced by the hysteresis in the iron.
27. Infinitesimal variation in the length of the iron core.
28. Movement of the armature, or hammer of the bell, striking the bell.
29. Vibration of the bell, beating the air.
30. Sound waves produced in the air by the vibrating bell.
31. Movements of the diaphragm of the second microphone, producing variations in the curvature of the diaphragm.
32. Variation of the pressure on the carbon balls, varying the resistance of the carbon, exactly in accordance with the number and amplitude of the vibrations of the diaphragm.
33. Pulsatory currents on the wire, producing electromagnetic flux around the wire.
34. Heat produced by the passage of the current over the wire.
35. Undulating magnetic force produced in the iron of the electro-magnet of the receiver.
36. Magnetic hysteresis in the iron formed in overcoming the molecular friction.
37. Heat produced by the hysteresis in the iron.
38. Infinitesimal variation in the length of the iron, due to the magnetizing currents.
39. Variation in the receiving diaphragm, producing variation in its curvature.
40. Air waves produced by the vibrations of the diaphragm.

41 to 50. Ten other similar transformations in the other carbon telephone and the telephone earpiece under the horn.

51. Sound waves through the air, out of the horn.
52. Vibrations of the tympanic membrane of the ear, imparting impulses to the inner ear.

53. Syntonic response of the chords of Corti in the cochlea.
54. Impulses along the auditory nerves to the brain.
55. Translation of these impulses into sounds.

The energy appeared as follows: Complex muscular contraction, once; electric current, eight times; magnetism, five times; mechanical pressure of the key, once; electric spark, once; ether waves, once; heat, ten times; contraction and expansion of iron, five times; molecular hysteresis, five times; vibration of the relay armature, once; atomic vibration of the bell, once; air waves, three times; vibrations of the carbon disks, twice; movements of the iron diaphragms, twice; change in the electric resistance of the carbon balls, twice; conversion of the coherer, once; vibrations of the chords of Corti, once; translation of nerve impulses into sound, once; vibration of the tympanic membrane, once.

There were fifty-five different translations of the energy, which was sent through twenty-one different media.

This series of experiments was varied at different times, and different sets of apparatus were employed; moreover, the number and variety of instruments could be enlarged indefinitely. In one case a selenium cell was employed, and sound waves were sent over a beam of light, as well as through other different media.

It can be readily understood that each set of apparatus thus employed was distinct and separate from all the others, and was connected up in an electric circuit of its own. It was in a state of balance, or

equilibrium, having energy, all its own, sufficient to operate its own parts; but it was waiting for the touch of the master energy to put it into operation and to direct the energy already within it into new and other channels entirely beyond itself.

At the present time, with the improvements and extensions of radio communication, by relaying it would be entirely possible to send out messages from one transmitter and relay them any number of times—and have them pass over a thousand or several thousand miles, and yet be heard in a million different places at one and the same time. In each case the same message would be received—such as greetings, instructions or words of cheer.

The parallels between these transformations of energy through numerous media and those which occur in Divine revelations are so exact and pertinent that they form virtually a demonstration of the ease with which God can send forth the energy of His will and word into the minds of men, and have it pass through endless transformations, yet remain His own truth, while superimposed upon the minds of men possessing their own independent energy of thought, and unerringly continue its directing course through human history until it returns to its Author the same energy as when He sent it forth on its enlightening and life-giving mission.

This process is so lucid and so strictly in accordance with scientific facts and laws that we do not see how any one who has even a faint willingness to credit it should fail to be convinced of the reasonableness of

the reliable, accurate, life-giving, "Thus saith the Lord," which the Scriptures declare themselves to be. "He speaks, the drooping heart to cheer."

When a man can with ease send out his energy in words and have them pass through numerous media and different electrically alive instruments possessing their own independent energy, and yet have another master energy superimposed upon them to direct and control them all sufficiently to have the words pass on in their journey, and at last return to the sender as distinct and as exact as when they were spoken—how, then, can we doubt that the Almighty can also similarly speak? Why doubt that He, too, can have His words and thoughts superimposed upon and pass through living and independent instruments, giving direction to their willing minds, and then proceed on through an endless variety of forms and media—and not return to Him empty but rather accomplish the purpose for which He sent them forth?

If I can lock my words in a steel wire or a steel disk, and then at any time call them forth at will, and have them appear as ether waves, electro-magnetic waves, mechanical energy, muscular contractions, nerve impulses, and so on—how very reasonable it is to believe that God can send His words to the brain cells of men, cause these to impress their minds, and be recorded on parchment in Hebrew, Greek or English symbols, and afterward call them forth at will to throb again in the consciences of men! He can call them forth to be recognized later as tears of repentance, or to be heard as songs of praise from the lips

of the thankful or as prayers from the spirits of believers, and at last to be returned to Him who had sent them forth.

We have now arrived at the point at which we can see how the thorough and reverent study of science leads to God. When certain conditions are fulfilled, such as are demanded in order to secure successful scientific demonstrations, such as those outlined above, then all scientific research can find its terminus in devout trust in God.

In all those experiments there was a kind of catalysis manifest. That is, the mere presence of a certain given object is sufficient to bring about marked changes in the character of different substances without itself being changed in the slightest degree.

Some supersaturated solutions seem unable to initiate the process of crystallization until a crystal of the substance is dropped into them; but when this new substance has been added, they immediately solidify into crystals.

Very often chemical reaction is unable to occur between substances until another substance comes into contact with them; then they at once unite to form a new thing. For example, hydrogen and oxygen gases will not combine when simply mixed, but if a piece of spongy platinum be placed in the mixture, they will combine immediately, though the platinum undergoes no change whatever. Many chemicals thus perform the office of catalytics. Catalysis is believed to be a kind of induction which is common through the whole domain of physics, chemistry and electricity, and

probably in vegetable and animal life, also. A magnet simply being in proximity to, not in contact with, magnetic bodies induces a magnetism in them; and a living cell compels other cells to form, similar to it, by the mere fact of being adjacent.

The energy in the experiments just enumerated changed and directed the energy latent within the different instruments, yet itself was not changed but continued on in its course through all the different media.

God's word, God's energy, is a catalyzer. It brings about combinations, transformations and changes in all that it touches, and yet it remains, like its Author, itself unchanged.

The conditions requisite for successful experiments in the conservation of energy are these: First, there must be a surrender, or subjection, of all instruments to the force acting upon and through them. This is the first law of success in matters of science and as well in things pertaining to man's spiritual relation to God.

The second requisite is receptivity. The energy transmitted must be received. In order to this, there must be a state of equilibrium, or readiness to receive the touch of the new, transforming and directing force. In things spiritual the receptivity is a readiness to welcome, as a guest, the Force from on high. This is the attitude assumed when one says, " Speak, for Thy servant hears."

Then there must be insulation. Not an experiment in electricity could succeed, not a telephone or wire-

less apparatus could exist, apart from this aloofness of a thing from its environment, called insulation. One needs to separate himself from his former conceit, self-will, evil deeds, his associates, and possibly life itself; then the new Breath of God transforms and directs his energy.

The last of the requisites to successful experimentation in energy conservation is continuity. Continuity must be maintained between the instruments and the energy moving upon them. The instrument may be the air or the ether or an iron core of a magnet or an insulated wire, but there must always be some kind of continuity preserved. That is, there must be a more or less defined similarity or harmony between the instruments and the transforming agent.

Now, the great secret of an assured faith in God, is the maintenance of contact with Him. As a discordant note breaks contact in radio communication, so a breath of evil encouraged or tolerated breaks the contact between God and the heart of man.

Only that which is divine is faultless, and so God can be pleased with only that which emanates from Himself. In Christ He perfects a contact between Himself and all willing recipients. He then imparts to them His life, His love and His holy motives. Thus made like Him, they experience a loving continuity or fellowship with Him as their Father.

When these four conditions imposed by the laws of science upon the different pieces of apparatus are complied with they issue in marvels both astonishing and beneficent.

Let any person pursue the study of science in the spirit already indicated, fulfilling, in his relation to God, the conditions just outlined, and he will discover that Nature is indeed a medium in the revelation of spiritual truth—that light has risen in his obscurity, and his darkness has become as the noonday. He shall go out with joy, and be led forth with peace; the mountains and the hills shall break forth before him into singing, and all the trees of the field shall clap their hands. And his pathway shall be illuminated with a light which shall shine more and more unto the perfect day; and at eventide it shall be light.

INDEX

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